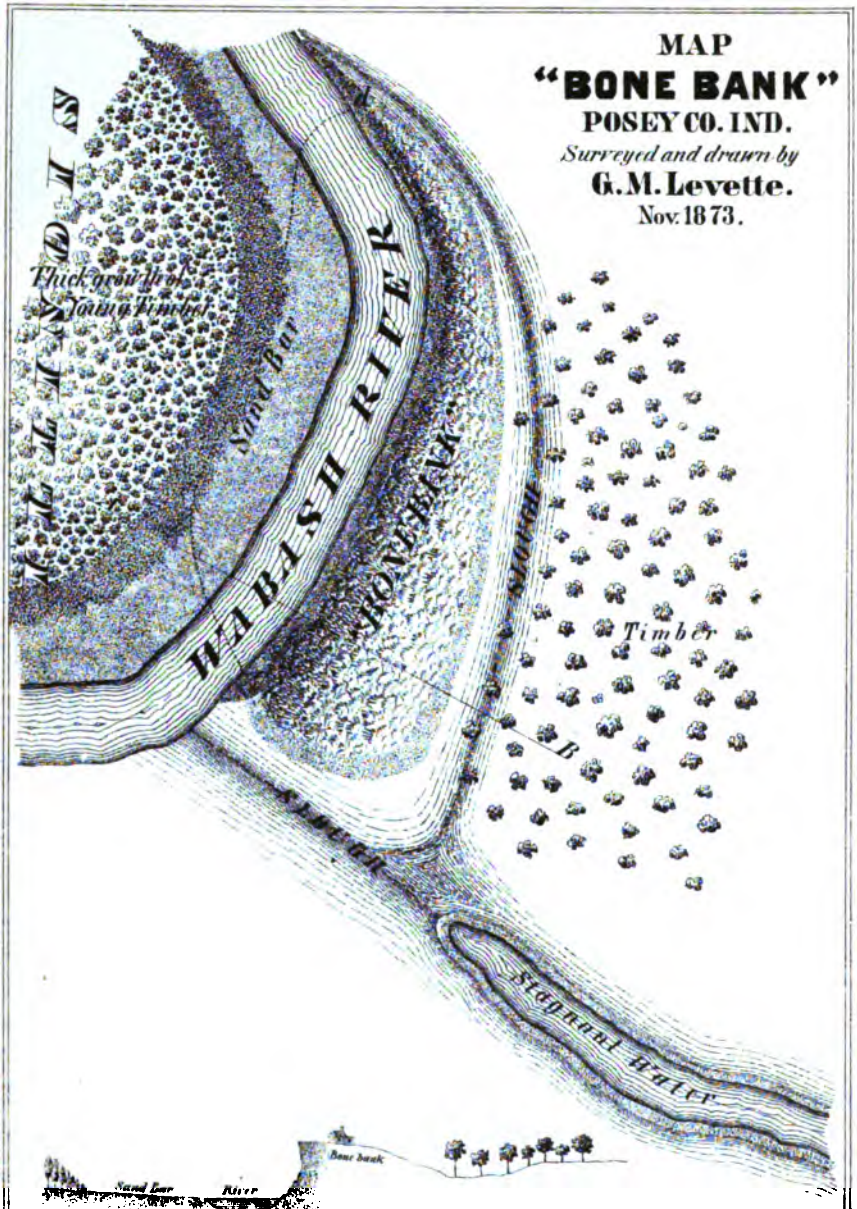


Section through A.B. Bluff 35 ft. above water 12th Nov. 1873.

The dotted line c. d. shows the probable western outline of the "Bone Bank" within the memory of the present inhabitants.

3,

FIFTH ANNUAL REPORT

OF THE

Geological Survey

OF

INDIANA,

MADE DURING THE YEAR 1873,

BY

E. T. COX,

STATE GEOLOGIST;

ASSISTED BY

PROF. JOHN COLLETT, PROF. W. W. BORDEN, AND DR. G. M. LEVETTE.

INDIANAPOLIS:
SENTINEL COMPANY, PRINTERS:
1874.

OFFICE OF STATE GEOLOGIST,
INDIANAPOLIS, INDIANA,
December 1st., 1873.

To the Hon. President and Members of the
Indiana State Board of Agriculture:

SIRS:—I herewith submit to your honorable body my Fifth Report of progress in the Geological Survey of the State, embracing observations made during the year 1873.

Very Respectfully,

E. T. COX,
State Geologist.

REPORT

ON THE

VIENNA EXPOSITION OF 1873.

Under an Act of the General Assembly of the State of Indiana, I was appointed, by His Excellency, Thomas A. Hendricks, Governor of the State of Indiana, Commissioner to represent the State at the Universal Exposition to be held at Vienna, Austria. From the date of my commission, given immediately after the passage of the law, but ten days could be relied upon for collecting together such natural products of the State as were deemed important to properly represent our resources in agriculture and mines. It was found impossible in so short a time to make a showing of the agricultural products of the State that would do even half way credit, in this line, to her great resources, consequently the few specimens gratuitously sent in for the purpose were not thought of sufficient importance to be shipped, believing it was best to leave undone that which could not be made creditable to a State so justly celebrated for the products of its soil.

In order to be able to exhibit samples of native timber, I could do no better than employ Mr. O. B. Gilkey, an experienced carpenter of this city, to visit the nearest saw mills

and procure sections of such logs as they chanced to have on hand; and though we were unable, in this way, to get specimens that approached near to the maximum size of our giant forest trees, and that would even reach the medium size of some of the species represented; still, taken as a whole, they might be considered as exhibiting the average diameter of timber daily received at the mills of this city.

Of the more than ninety species of trees in the State we were only able to get the following:

Poplar, black and white walnut, red and white oak, elm, maple, sycamore, beach, cherry, hickory and ash.

Mr. B. F. Morris, Superintendent of the Sewing Machine Cabinet Company, furnished me with a collection of veneering cut from a variety of our most beautiful cabinet woods. This, collection, imperfect as it was, elicited much attention at Vienna, and, with the exception of a few pieces of plank from Louisiana, comprised all the timber I saw on exhibition from the United States.

The display of woods from Brazil, Austria, and especially Hungary, was large, and in point of beauty and finish the Hungarian ash was not surpassed, if equalled, by any timber on exhibition.

In minerals, especially coal, I was enabled to make a better showing. Large, characteristic specimens of Caking coal, Block coal, and Cannel coal, were obtained from mines in various counties of the State. Along with the coals were specimens of pig-iron smelted with raw block coal, clay iron-stone from the coal measures, fire clay, fire brick made from the clay, building stone and specimens of various colored ochres from Owen, Greene, Martin and Dubois counties.

The specimens shipped reached Vienna in good order, and through the kindness of my friend John A. Warder, M. D., Commissioner from Ohio, they were very advantageously arranged near the center of one of the transepts in the United States Department.

In addition to the natural products of the State I prepared a pamphlet, of which eight thousand copies were published

in English and German, for distribution along with the Geological, Agricultural and School Superintendent's Reports. Col. W. R. Holloway also sent over a box of "Holloway's History of Indianapolis," to be given to those who desired them. In the distribution of books treating of the mineral, agricultural and educational advantages of this country, our State was unsurpassed, and it cannot fail in producing good results.

The coal and iron, especially the fine large cubes of block-coal, were examined with the greatest interest by the European iron masters, and was of no less interest to the International jury who were appointed to examine into the character and merits of all the minerals on exhibition. This jury was made up of distinguished geologists and mining engineers from the different countries, and after a careful examination of its merits made the State an award of a medal.

The display of fossil fuel, at Vienna, from the various countries of the Old World, was large and very fine, some of the most important mines sending large blocks that represented a section of the entire thickness of the seam. All these thick seams represented, show a number of clay or shale partings which divided it into so many members, each varying from the others in its physical structure and apparently with regard to the amount of pyrites or sulphur stone which it contained.

A block from Kadno, Bohemia, was six and a half metres, or twenty-one and one-third feet thick, and contained five well defined partings or bands of clay and shale. The depth of the shaft to the coal is two hundred and eighty meters, or nine hundred and eighteen and a half feet. It is a caking coal, shining black color, somewhat friable, and the seams are filled with scales of calc. spar. It appeared to be comparatively free from pyrites, and the coke made from it looked strong and good. Another great pyramid of coal, on exhibition, was from Kubekschacht, Bohemia; depth of the shaft three hundred and sixty meters, or eleven hundred and eighty one feet. This seam is 11.4 meters, or thirty-

seven feet thick, and contains seven clay partings of considerable thickness. Both the coal and the coke made from it, looked to be of a good quality. West Bohemia sent some fine large blocks of cannel coal and a beautiful display of jet ornaments made of it; such as cups, vases, goblets, etc., etc., of which the color and finish was good.

The coals of Belgium were also extensively displayed, and they are among the best coals of Europe for coking.

From Italy there was a variety of specimens of brown coal showing woody structure; peat and charcoal, and specimens of the wood from which the charcoal was made, which indicated that mere bushes or saplings were appropriated for the production of the latter kind of fuel.

The pig iron, finished bar iron and steel made with these fuels was of good quality. Spiegeleisen was also one of the metals in this collection.

India had coal which in character is midway between brown coal and a bituminous coal, and a large and instructive collection of other economical minerals which abound in that interesting country. Indeed, owing to the indefatigable industry of Dr. T. Oldham, Director of the Geological Survey of India, and his accomplished assistant, Mr. R. Bruce Foote, this was made one of the most attractive geological and mineralogical displays in the building. The India coals are supposed to belong to the lower Permian epoch, a position just above the true coal measures. Some of the specimens on exhibition looked very good, and coke made of them appeared to be a very fair article for metallurgical purposes, but it will be seen from the following summary of analyses, kindly furnished me by Dr. Oldham, that they must take a very low rank as a fuel on account of the large per cent. of ash which they yield. Of seventeen specimens analysed the total carbon ranged from 39.2 per cent. to 63.8 per cent., the water, oxygen, nitrogen and hydrogen from 25.6 per cent. to 38.5 per cent., the ash from 11.2 per cent. to 35.2 per cent.

The ash from two of the most largely used of these coals contained:

	No. 1	No. 2.
Silica - - -	48.3	42.0
Alumina - - -	32.4	31.3
Peroxide iron - - -	7.5	10.1

To judge by the large per cent. of water manifest in these coals, one would be inclined to give them a much higher place in the geological series than the Permian. The seams are from six and a half to seventeen and a half feet thick, and the depth of the shafts from seventy-seven to two hundred feet. In 1858 the amount of coal raised in India was 221,000 tons. In 1868, 484,370 tons, being rather more than one hundred per cent. increase in ten years.

A very fair quality of fuel is made in India by mixing the coal debris with rice water, then press the mass in a mold and dry it in an oven at a temperature of about 250° Fahr. But, as I have said, coal formed only a very small part of the economical minerals displayed from this rich country, and Dr. Oldham deserves great credit for placing before the visitors the wonderful resources which his survey has brought to light.

A very interesting section of brown coal was exhibited from Moravia in the Austrian department; it contains seven seams of coal separated from one another by thin clay partings. All together they represented over twenty-six feet of coal, Brown coal, though rather a poor fuel, is extensively used in Austria, Germany and other parts of Europe for household and steam purposes, the railroads being very good customers. For the latter use it is mixed with bituminous coal.

Probably, next to bituminous coal, peat or turf ranks as the most important fuel in Europe. All the sections of the Exposition, except the American, contained a good display of it, both as sun dried cubes and balls and as partly charred masses and coke.

Several models of ovens for coking turf were also on

exhibition, and when properly coked it makes a fuel that is not to be despised, even for metallurgical purposes.

In Austria, Bavaria and Switzerland, sun dried turf, mixed with bituminous coal, is extensively used on the railroads. The shed depots in which it is stowed for use resemble great barns. In the Austrian, Russian, French and Belgian departments, there was also exhibited specimens of fuel manufactured from coal dust mixed with some kind of bituminous oil and formed under great pressure into cubes or hollow tubes. But I saw nothing new in the processes used in the manufacture of artificial fuel, in the washing of impure coal or coal debris, or in coal mining machinery. And so with coal mining in general and the metallurgy of iron, there was little or nothing to be seen that was new beyond a greater perfection in the machinery in some parts of the latter department of industry.

After a careful study of the fuels so bountifully displayed at this great exhibition, from the four quarters of the globe, our countrymen could not help feeling how blest was the United States in this essential element to progressive arts and the welfare of man, and yet how meagre was the display which she had made. I trust, too, that I may be pardoned for the pride I felt in the exhibition of coal from Indiana, which looked none the less bright and good by comparison with the coals of the nations to which it was subjected. In the iron and steel departments, each country of Europe made a magnificent display. Here it was that the genius and power of man to subdue and render submissive to his will the dead minerals of the earth could be studied in the greatest perfection.

By the side of the crude iron ore and coke was seen the rough pig metal and bars of finished iron and steel, from sheets not thicker than ordinary writing paper to immense armor plates and shafts of wondrous size. Indeed, to go over all the ground in this department would fill volumes, and I cannot do better than introduce, instead of my own imperfect study of the resources of Europe in this branch of industry, a paper from my learned friend Hugh Hartmann,

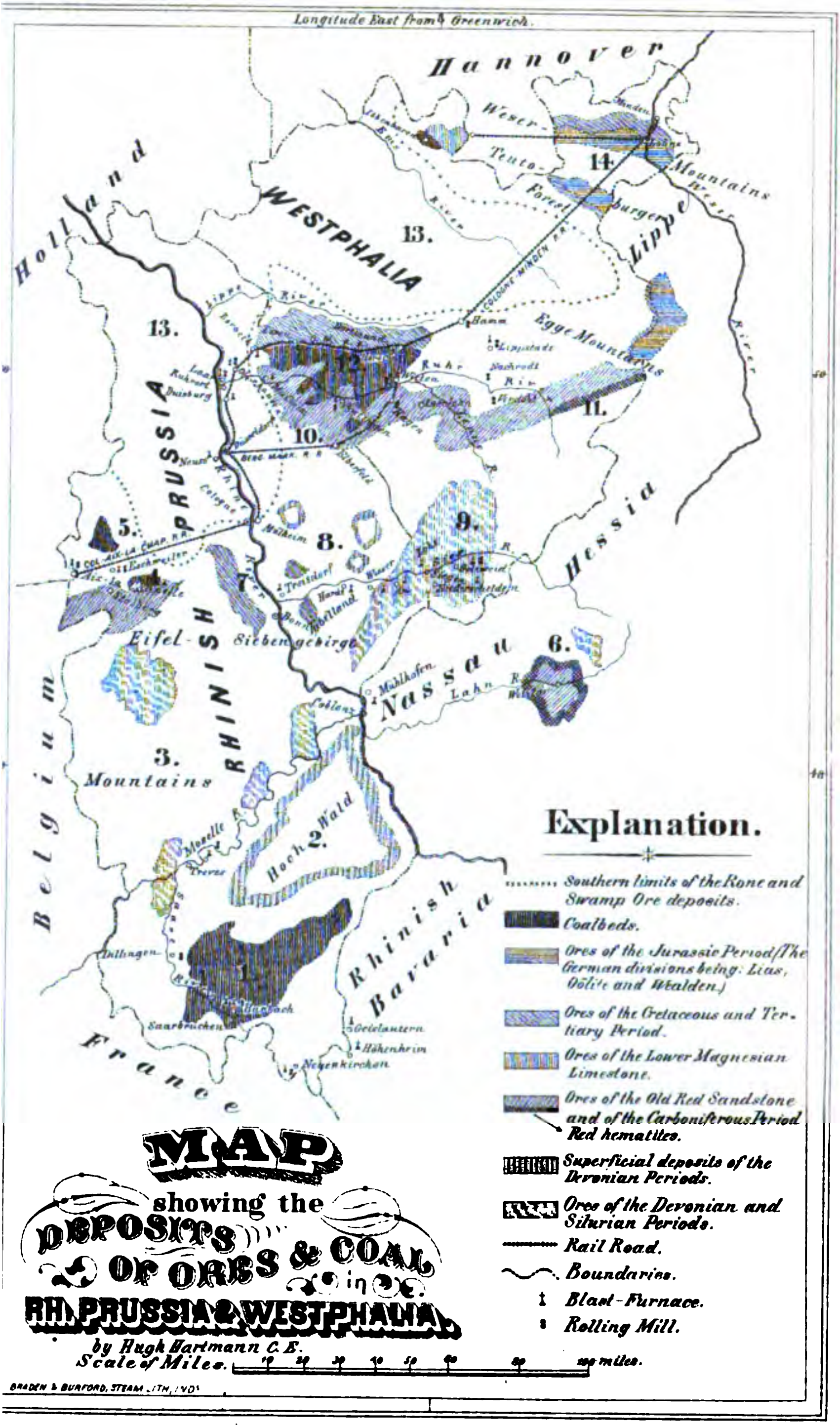
C. E., on the iron and steel industries of Rhenish Prussia, one of the most important iron manufacturing districts of Europe. Mr. Hartman was for many years connected with the iron business of this country, and his paper cannot fail to be read with the greatest interest by those who desire to learn of the resources of districts which are becoming alarming rivals of the English iron masters, for even their home market.

The wonderful growth of the iron industry all over Europe, and no less in our own country, has brought the iron masters to seriously consider the extent of the ore and fuel beds at their disposal. Nowhere has this question met with a more serious and intelligent study than in Great Britain, where with a rapid increase in the cost of coal, ore and labor, her long and well earned fame as manufacturer for the world, is about to be questioned by her continental neighbors, and by this country, which has heretofore been her best customer.

At the time of my visit to Middlesborough, the capital ot the Cleveland iron district, in the north of England, coal was selling at twenty-two shillings ($5.50) per ton, and Durham coke at forty-two shillings ($8.50) per ton. Cleveland iron stone, containing, on an average for raw ore, thirty-one per cent. of iron, was selling at thirteen shillings ($3.25) per ton at the mines. Even with this price for ore I was told that there were fully eight thousand ore miners on a strike for an increase of wages, whose demands, if complied with, must add to its cost. Pig iron made from the Cleveland iron stone was selling at one hundred and ten shillings ($27.50) per ton, which was anything but remunerative at the existing cost of coal and ores and the high price of labor involved in its production. At Middlesborough I received the kindest attention from the iron masters, and feel myself greatly indebted to Mr. John A. Jones, of the Ayrton Rolling Mill, and one of the Commissioners sent to this country, by the Iron and Steel Institute of Great Britain, to investigate the practical working of the Danks Machine Puddler. Mr. Jones took me to the Cleve-

land Hills, where we were hospitably received by Mr. George Lee, Superintendent of the Easton mines, and his son. The ore seam is here fifteen to twenty feet thick, and has an elevation in the hills of eight hundred feet above the plain of Middlesborough. About three thousand tons are mined daily. The miners are paid from seven and a half pence (15 cents) to fifteen pence (30 cents) per ton. About 2,500,000 tons of this ore are smelted annually in the Cleveland District; which produces from one-third to one half of all the iron made in the Kingdom. Frem the Easton mines we could look down upon the fires of one hundred and one blast furnaces that are smelting this lean ironstone which lay neglected and uncared for until within a few years past. All that now prevents this highly favored district from continuing in its brilliant career of iron production is the corresponding increase in the cost of coal, coke and ore. With these facts staring iron masters in the face they do not fail to see that if the increase of consumption of iron and coal continues in the present ratio for ten years to come, that demand must be met by the growth of the iron industries of America.

The immense coal and iron fields of the United States, many parts of which have been looked upon as worthless on account of their remoteness from lines of transportation, are being rapidly developed and made accessible to market by railway lines, so that good coal and iron ores, instead of increasing in value as in Europe, will become cheaper; and though labor may still command a higher price here than there, we are, nevertheless, fast approaching a point of development where defiance may be bid to the competition of the world in the manufacture of iron and steel.


Longitude East from Greenwich.
Hannover
Weser
Teuto-
Forest
burger
Mountains
Lippe
Westphalia
13.
14.
Holland
Lippe River
Hamm
Egge Mountains
Ruhr
Ruhrort
Duisburg
Prussia
Cologne-Minden R.R.
10.
11.
12.
Neuss
Rhine
Cologne
Mülheim
8.
9.
5.
Col.-Aix-la Chap. R.R.
Eschweiler
7.
Bonn
Siebengebirge
Eifel-
Rhinish
Hessia
6.
Nassau
Lahn
Mühlhofen
Coblenz
3.
Mountains
Moselle R.
Treves
Hoch 2. Wald
Belgium
Dillingen
1.
Saarbrücken
Rhinish Bavaria
Geislautern
Hohenheim
Neuenkirchen
France
Explanation.
Southern limits of the Bone and Swamp Ore deposits.
Coalbeds.
Ores of the Jurassic Period (The German divisions being: Lias, Oölite and Wealden.)
Ores of the Cretaceous and Tertiary Period.
Ores of the Lower Magnesian Limestone.
Ores of the Old Red Sandstone and of the Carboniferous Period
Red hematites.
Superficial deposits of the Devonian Periods.
Ores of the Devonian and Silurian Periods.
Rail Road.
Boundaries.
Blast-Furnace.
Rolling Mill.
MAP
showing the
DEPOSITS
OF ORES & COAL
in
RH. PRUSSIA & WESTPHALIA,
by Hugh Hartmann C.E.
Scale of Miles. 10 20 30 40 50 60 80 100 miles.
BRADEN & BURFORD, STEAM LITH, PRO.

THE IRON AND STEEL INDUSTRIES

OF

RHENISH PRUSSIA AND WESTPHALIA,

GERMANY,

AT THE

VIENNA EXHIBITION OF 1873.

WITH A MAP.

BY HUGH HARTMANN, C. E.

Besides the two Austrian mining districts, Corinthia and Styria, which were very careful in the display of their products, it was mostly the representation of the iron and steel industry of Rhenish Prussia and Westphalia which not only made the greatest impressions upon the common visitor, but which offered, also to the iron masters themselves many points of information and instruction.

Other mining and iron-producing parts of Germany, even Silesia, did not bring before the eyes of the public such displays of their products and, indeed, great mineral resources, as they, considered the unmistakable value of such a World's Fair, ought to have done. It is for this reason, that the two provinces named evidently represented the totality of the iron industry of the German Empire compared with other foreign countries, like Austria, Belgiam, France, England, and others. And they have done it in a good and interesting manner.

The iron and steel industry of these two provinces is based upon:

1. Good-natured iron-ores, and

2. Bituminous coal beds which reach from Belgium through Rhenish Prussia into Westphalia, and from France into the district of Saarbrucken, the south-west corner of Rhenish Prussia.

The iron masters, especially those of the Lower Rhine, are not confined to the use of ores of their immediate vicinity, notwithstanding that there are in both provinces large deposits of ores; they work, also, ores of provinces of the surrounding states, and even from remote countries, such as Spain, and the northern coast of Africa, Sweden and Norway.

It is evident, that with such manifold materials, the conducting of the blast furnaces must be very interesting, but I may add that it is also very difficult on account of the many different properties of the ores to be treated.

The iron manufacturing districts are grouped according to the existence of the raw materials. Either the ores or the coal form the centers of the district, corresponding with the respective money value, contents and general properties of the same.

There are in all four decidedly bounded groups which can be enumerated, viz:

1. The iron works of the Saar coal beds, including the furnaces and rolling mills on the Moselle within the boundaries of Rhenish Prussia.

2. Those of the District of Aix la Chappelle, within the coal beds on the rivers Inde and Worm.

3. Those of the Lower Rhine and Westphalia, which extend in a long line from Heuss, Dusseldorf, Duisburg, via Doitmund, as far as the upper parts of the rivers Lenne and Ruhr.

The county "Mark," the oldest seat of Westphalia iron industry, forms still the geographical center of this widely

extended line (the cities Doitmund, Witten and Hagen being also the principal market places for the iron trade), while it is flanked easterly by the territory of Arnsburg, and westward by those of Essen and Duisburg.

In connection with this third group, which is the most important one regarding quantity of production and business performed, there is to be enumerated also an outpost ot Westphalia, as I may call it, situated more to the northwest, and nearer to the coast of the Northern Sea, the district of Osnabruck. This somewhat remote district, belonging geographically to the province Hannover, is strictly connected with Westphalia by its commercial and other interests.

4. Those in the neighborhood of the ore beds of the territory of Siegen, Wetzlar and including the furnaces on the river Lahr and near Neuwied on the Rhine.

There are only a few remarkable differences in the physiognomy of these four groups, appearing in the peculiarities of those materials, which are the most accessible ones. While on the one hand the blast furnaces of the territory of Siegen are mostly working sparry ores, and those on the borders of the Lahr red hematite, the furnaces around the city of Saarbrucken on the other hand smelt frequently the oolitic ores of Luxembourg and Lorraine, the furnaces of Westphalia, the black band of the coal formation and those around Osnabruck the ores of the magnesian limestone. But these distinctions will be compensated more and more, because good and rich ores can be worked upon at any locality of the provinces in which they are found, provided that the second principal material—coke or coal—is at hand in close vicinity. The moveableness of the iron industry, i. e. the free choice of the raw material would be, even at present, a far greater one, if the means for transportation were shaped in a manner more corresponding with the interest, prosperity, and the increase of the industry itself. There is without any doubt a great progress made in this regard of late years; but the vivacity, the spirit of enterprise,

which so highly characterizes the American people, are still needed to a great extent.

The manufacturing of wrought iron and steel is mostly confined to the presence of coal alone. Exceptions are the environs of Siegen, Osnabruck and Neuwied, but the fabrication of the articles named there, has not yet reached the extent of business of the other districts.

The use of charcoal for fuel is nearly abandoned. Only to certain qualities it is in some cases still applied, but the art of iron manufacturing is progressing in such a manner, that even such sharp distinctions between iron made with charcoal and such with coke, will soon become of historical interest only.

At Vienna the four different groups were represented by about seventy firms, while upper and Lower Silesia, both very well known for their iron products and situated almost in close proximity to the Austrian Capital, were represented only, the former by eight, the latter by two companies.

THE FIRST GROUP

occupies the most southwestern part of Rhenish Prussia. Like at other places of Germany and elsewhere the most important mines are worked in the most ancient strata of the coal measures. The country in question and the adjacent parts of France represent several groups of small mountains which are of primitive formation on the ridges and of transit state on the flanks. In the sinuosities between occur the deposits of coal, which have become the great centers of manufacturing.

The coal basin of the Saar, a tributary of the Moselle, near the frontiers of France, affords a very important and extensive field of bituminous coal. Of this field, represented on the accompanying map in Fig. 1*, not less than 103 beds are described, the thickness varying from 18 inches to 15

*For the better or easier understanding the different coal and ore beds, related to in the text, are numbered on the map.

feet. Alongside the coal, nature itself has deposited iron ores, the intrinsic value of which alone is very small, indeed, but whose abundance in the neighborhood of the fuel becomes extremely precious. The coal beds bear many gangues of clay iron stones, of which more than one hundred are known; there occurs, also, some black band and some red hematite in the vicinity of the city of Saarbrucken, but the mining of all these ores together, is not sufficient to supply the requirements of the blast furnaces of this group. To a great extent ores from Lorraine, Belgium and Luxembourg are imported. The ores, mined on the Maas, the Moselle and in the Ardennes and Vosges, are partly brown hematites, which are found either in veins or in large masses, embodied in the Lias (one of the foreign divisions of the Jurassic period, which is divided in Lias, Oolitic and Wealden) or in clay formations overlaying the former, partly granular ores of the same formation (Lias) or of the chalks.

The latter (granular) ore, occurring in pieces of nut size or lens shape, is accumulated by means of a clayey, or an iron containing calcareous paste to very extensive beds. The mines near Metz and Nancy, which are worked upon this ore, are on a very large scale.

The principle ores of the Vosges (Lorraine) are red oxide of iron and brown hematite, which form veins of great thickness in districts composed of greenstone, limestone and graywacke. Near the sources of the Moselle, in the Vosges, there are also beds of iron ores which traverse formations of graywacke, clay, slate and porphyry. On the banks of this mountain range are veins worked upon powerful deposits of brown hematite and compact bog ore, accompanied with a great deal of debris.

The Luxembourg ores, of the northern part of the state, belong to the formation on the banks of the river Ourthe, as it will be described under the second group. Those of the Southern part belong to the Lias formation, which extends into Lorraine, as described above. The ores are found partly in veins, partly as superficial deposits, as granular

2

ores or in compact masses, embodied in an iron bearing clay of yellowish brown color.

On the southern and northern banks of the Moselle, after the river enters Rhenish Prussia and cuts its way through the Eifel Mountains, there are lastly superficial beds of brown iron ores and oolites (Fig. 2 and 3), the latter showing, when broken, concentric coals, the outside ones being very hard, but the interior becoming progressively softer towards the center, which is usually earthy and of light yellow color. The mountains in which these ores occur are secondary.

Some analyses of the new ores mentioned are the following: *

BROWN IRON ORES FROM THE BANKS OF THE MOSELLE.

The ore is porous, with yellowish brown and light brown stripes.

Peroxide of iron	85.10	81.30	69.50
Alumina	2.70	5.00	12.00
Lime	12.20	1.20	3.50
Phosphoric acid	——	0.60	0.00
Water	——	11.80	14.00
	100.00	99.90	99.20
Metallic iron	59.50	56.91	48.65

BROWN IRON ORE, COMPACT.

Protoxide of iron	65.18=Fe 50.69	
Alumina	3.78	
Magnesia	0.09	
Water	9.81	
Silica	21.10	and insoluble silicates.
Phosphate of lime	0.44	
Sulphate of lime	0.15	
	100.55	

* I shall give not only of this, but also of the following groups, some characteristic analyses which are mostly from private communications or from authorities like Rammelsberg, Karl, etc.

CLAY IRON STONE, COMPACT, DARK.

Protoxide of iron - -	35.00	
Protoxide of manganese -	trace	
Lime - - - -	1.50	
Alumina - - -	2.75	
Silica - - - -	4.55	
Phosphoric acid - -	0.10	
Clay and quartz - -	30.60	10.60 clay, 20.00 quartz
Water and carbonic acid -	23.00	
Organic matter - - -	2.45	
	99.95	

GRANULAR IRON ORE, BLACK BROWN; THE CONTENTS OF MANGANESE ARE VARIABLE.

Peroxide of iron - -	31.50	62.15
Peroxide of manganese - -	2.90	0.75
Alumina - - - -	2.00	0.80
Silica - - - -	0.25	3.75
Clay and quartz or sand - -	53.60	14.66
Water and Carbonic acid - -	9·30	17.72
Phosphoric acid - - -	——	0.12
	99.55	99.95
Metallic iron - - -	22.05	43.50

The total production of the mining districts of the Maas, Moselle and Ardennes was in 1872,......................669,205 tons of ores.
Of the Vosges................................. 24 920 tons of ores.
Of the Saarbrucken.......................... 42,200 tons of ores.

To enumerate all the iron establishments, etc., which were represented at Vienna, would be of no use to the reader in this country. Only such of this group, as well as

of the following, which are in fact prominent, shall find a place in this description. With this point in view, I cite:

1. THE LUXEMBOURG MINING AND SAARBRUCKEN IRON WORKS COMPANY AT BURBACK.

The Company has four blast furnaces, built in 1856, which are from 48 to 50 feet high. The square contents of the boshes and those of the mouth of the furnaces are of a proportion=1: 0.25 to 0.286. They are blown with three or four tuyeres which have a diameter of 1½ to 2½ inches. The pressure of the blast air varies from 2.85 to 4.4 lbs. per square inch and has a temperature from 250-300° C. (480-570°F). The coke used for fuel is made in 131 coking furnaces, of coal of the Saarbrucken beds, which is very good, containing very little ashes and giving a hard, but porous coke, weighing about 26.5 lbs. per cubic foot. The amount of coke required per one ton of pig iron is:

For white pig..3000 to 3300 lbs.
For gray pig.................. ....4000 to 4800 lbs.

The ores worked by this Company are mostly from mines near Nancy and from Luxembourg, the mines being the property of the Company. Of the brown iron ores, the two different classes are melted, one being of the compact quality, the other being a soft, clayey ore. With the intention of cleaning the ores from the merely mechanical admixtures which are in several respects of an unfavorable influence to the smelting process, they are washed. The washed ores contain from 35 to 40 per cent. of metallic iron, and bear often bands of an excellent calcareous matter. Red hematite from the borders of the Lahn is also used.

The production of the four blast furnaces amounted to 50,000 tons in 1872, or per day and each furnace to about 70,000 pounds.

The rolling mills of the company, comprising 56 puddling and 21 balling furnaces, with 10 pairs of puddle and finishing rolls, converted the above amount into 42,000 tons

of wrought iron. Half the quantity of this latter product were beams, girders and other materials for building purposes, while the rest consisted of rails.

The company displayed at Vienna a collection of girders of the most different profiles. Well known are the rolling mills for the manufacture of single and double T supporters, which are produced to a length of 70-72 feet. Those exhibited at Vienna were of a length of 54, 59 and 70 feet.

2. MESSRS. STUMM BROS., OF NEUENKIRSHEN.

The iron establishments of these gentlemen were, in past times, a domain of the Duke of Nassau, but went into the possession of the French Republic in 1792, and in 1806 into the hands of the present proprietors. The total technical apparatus of this establishment was, in 1872, 6 blast furnaces, 192 coking furnaces, 2 cupola furnaces, 52 puddling, 18 balling furnaces, 11 sets of roughing and finishing rolls, which are worked by means of 71 steam engines of a nominal power of 7,466 horses, 14 steam hammers, 7 water wheels and 90 steam boilers.

The total production amounted to 39,644 tons of rails, 910 tons of merchant iron, and 2,616 tons of cast iron. Two more blast furnaces and 96 coking furnaces are in progress of construction. The display of the firm consisted of a collection of ores illustrated by chemical analyses, pig iron, cast work, profiles of wrought iron, etc.

3. MR. KRAEMER'S IRON WORKS AT QUINT,

Near the old and well known city of Treves, (the Roman "Castra Trevirorum" in Cæsar's "De Bello Galluo,") or Frier, as the Germans call it. This establishment is a very old one, erected about one hundred years ago, containing at present 5 blast, 45 puddling and 12 balling furnaces. The production of 1872, with a force of 1,200 workmen, was 18,000 tons pig iron

and 22,500 tons of wrought iron (the latter including a great amount of pig, bought in open market). The market for the products of the establishment is the next neighborhood and the S. E. of the province. The coal is from Saarbrucken, and also the additional pig iron. The building of the Moselle Valley R. R. will give a new impetus to the establishment.

The display of iron ores, chiefly representing such of the vicinity of Frier, was extraordinarily complete, and of great local interest. Specimens of pig, profiles of wrought iron, cast iron pieces, water tubes, gas pipes, bells and machinery, were remarkably exhibited. Of special notice was a peculiar method of suspending large bells, by means of pinion nd rack, combining, to a certain extent, security and moveableness.

4. GERMANIA IRON WORKS, S. F. BUDERUS, PROPRIETOR.

Established in 1844 by I. Glayer. This rolling mill is well famed for the manufacturing of sheet iron and galvanized iron for roofing purposes. The establishment contains 14 puddling, 6 balling and 9 re-heating furnaces, with 6 sets of rolls. The production in 1872 was 2,750 tons common, and 840 tons galvanized sheet iron; 500 workmen were employed in this fabrication.

5. DILLINGER IRON WORKS COMPANY,

at Dillinger on the Saar. The company was formed as far back as 1763, and owns now iron mines near Saarbrucken, in Nassau, Luxembourg, Lorraine and France, blast furnances and rolling mills at Dillenburg, Geislautern and Hohenheim. While the manufacture of pig iron chiefly takes place at the two latter named places, the rolling mills are concentrated at Dillengen. The specialty of the company is fine charcoal sheet iron, but besides this any kind of wrought iron, beams, girders, trusses for bridges, boiler plates and plates for water cisterns, etc., are manufactured. The total production of 1872 amounted to 24,000 tons of

wrought iron; the working force numbers about 2000 men. The best proof of the extension of the labors of the company, were the collections exhibited at Vienna. Among others there were iron plates for bridge building, 3.28 feet wide, 13.45 feet long, weighing 2,300 lbs.; a boiler plate 6.24 feet wide, 21.13 feet long, weighing 2,130 lbs. The good quality of the iron was directly proved by some objects of cutler's work; excellent sheet iron was displayed for the purpose of button manufacturing.

Concluding with this short description of the larger companies of the Saarbrucken district, this first group, I do not omit to state that there was still a remarkable number of exhibitors at Vienna which I do not enumerate for want of universal interest, but which have surely great local importance. Some well managed foundries, machine shops for agricultural implements, and others are well famed for their products among customers at home and at a distance.

THE SECOND GROUP.

The iron works of this group ore founded upon the coal and ore beds marked upon the map, Figs. 3, 4 and 5, and also upon the use of Belgian ores.

The coal beds on the rivers Worm and Inde, have a certain connection with those of Belgium, of which that of Hainault is the most important one, covering an area of 200,000 acres, and of which the beds of this group are the north-eastern continuation. The number of coal seams is very considerable, but the layers are thin, and often very much disturbed, so as to require special modes of working. The quality of the coal is also very variable; it is a bituminous one, burning rapidly, with much flame, thus giving an intense heat. Sixty different seams of coal are known.

The Belgian ores, extensively used in the furnaces of this group, in general belong to the limestone of the coal measures; they are partly brown, soft hematite, partly hard, red hematite. North of the banks of chalk, which outline the coal beds on the river Sambre, there is a belt of slate

which separates the former from following formations of chalk and dolomite, while the latter more northwards are followed by another belt of slates. It is in the zone of chalk where the brown hematites chiefly are found, while the red ores are contained in veins of the slate. The red ores are coarse grained and composed very regularly of reddish blue and blue gray, lense shaped pieces agglutinated by red paste. The brown ores are not of so good a quality as the red ones.

Argillaceous iron ores of the coal beds on the Worm are mined to a limited extent, while those of the Inde coal beds are not worth mining. Near the line of these beds there are also ores of hydrate of iron, occasionally zinciferous, in the transition rocks, where they form sometimes veins, sometimes irregular deposits. This ore is partly explored by open quarrying, partly by under-ground working.

The ores of the Sifel Mountains (Fig. 5), southward of the Worm and Inde, and thence to the Moselle, are very numerous; it is brown iron ore, superficially deposited, but very often going down to a great depth in veins. Some spathic ores are also found in this region.

Analyses of some of the ores mentioned are the following:

RED HEMATITE.		
Peroxide of iron	83.5	82.5
" manganese	0.5	
Silica	10.0	
Alumina	1.4	
Carbonate of lime	4.6	
Earthy matter		17.5
	100.00	100.0
Metallic iron	58.45	57.75

BROWN IRON ORES.				
Peroxide of iron	31.5	59.0	72.8	44.5
Water & carb. acid	8.0	18.0	4.8	8.0
Gangue matter	59.5	22.0	21.0	44.5
	99.0	99.0	98.6	97.0
Metallic iron	24.05	41.05	50.96	31.15

I cannot omit to mention here two peculiar methods of preparing those ores which are agglutinated by that red, clayey paste, before they are brought into the furnaces.

The first method is successfully carried on at the Cornelia

mine, near Stolberg. The ore of this mine occurs partly in small pieces of nut size, partly entirely pulverized and mixed with clayey matter. The greater parts are firstly separated by hand work, and the rest intimately stirred up with water in a cylinder, in which a vertical shaft, upon which are mounted horizontal arms, constantly revolves. The thus produced slime is then conducted, by means of more water, to large cisterns. The coarse pieces remaining at the bottom of the cylinder are taken out and brought directly into the furnace, while the slime is allowed to settle down in the cisterns. From these it is taken out from time to time, formed in bricks and roasted. The roasted ore bricks contain from 40 to 43 per cent of metallic iron. The lighter clayey matter is allowed to flow off from the cisterns, while the heavier ore settles down. At Cornelia, seven workmen produce from two cisterns 50,000 lbs. of such bricks per 12 hours, at a cost of $4.25.

The second method, which is merely a washing process, is followed at such mines where the ores, occurring in the shape of grains, nuts, or small pieces, are merely agglutinated by clay, which is of no use in the furnace. The ore is brought into wooden flues, water admitted, and the mass frequently stirred up. The flues are generally two feet wide, one foot deep, and from eight to twelve feet long, and have an inclination of two inches to one foot, i. e. about ten degrees. After being worked for some time with a rake, the slime is allowed to run off, while the remaining ore is taken out with shovels full of small holes. It is possible to wash in this way ten tons of ore, with eight to ten cubic feet of water in one hour.

A far better effect is insured in a washing by means of machinery, which is oftentimes used. The wash machine consists of a large cylinder, placed horizontally, with series of small pockets inside, which are arranged in the shape of spirals. The whole apparatus is revolved by a steam engine. With such a cylinder of twelve feet length, five feet diameter, and a direct acting engine, which has a steam cylinder of 10.35 inches diameter, and 16.07 inches stroke,

2,500 pounds of ore can be washed in one hour, the total expense per 100 lbs. of washed ore being less than two cents.

The dimensions of the furnaces of this group are the same—unimportant differences omitted—as generally used throughout Belgium, and the description of one may serve as a guidance more or less to all the furnaces related to below.

Height, total	50 feet.			
" of the center of the tuyeres from the bottom	2	feet,	6	inches
" of the hearth	7	"		
" of the boshes above the bottom	19	"	3	"
Diameter of the mouth	8	"		
" of the boshes	15	"		
" of the hearth, above	3	"	6	inches
" of hearth below	3	"		

Each furnace is generally blown with three tuyeres, and there are attached to each stack two or three hot-air stoves, for there is at present a great inclination to have the temperature as high as possible. The system of the stoves is different, as described under the third group.

The coking furnaces are mostly of Dubochet's system, which was invented by Mr. Pouwels, engineer of the gas works of the city of Paris, and which are built on a grand scale at the coking establishment of Madame de Wendell, near Saarbrucken. This system, by which the furnaces are charged, without interruption, from above, and discharged from below, comprises fifty furnaces in one set; each coking room is charged with about five tons of coal, requiring about sixty hours for coking. Each furnace, when being in full operation, gives about 3,000 lbs. of coke per twenty-four hours, with a yielding of sixty per cent. of the coal. A few establishments make use of furnaces of Fabrŷ's system. These furnaces are small, only of a capacity of about 4,000 lbs. of coal, which are ready coked in twenty-four hours, and it is said that they yield from seventy to seventy-five

per cent. The charging and discharging can be done by three men in $\frac{1}{2}$–$\frac{3}{4}$ hour. These results are very good ones, but the erecting and maintaining of the furnaces is very expensive, and they are very fragile.

I give next a few figures to show the composition of the charges of the blast furnaces of this group, with a view of presenting a general idea of the manner in which they are conducted. Omitting the names of the establishments, (by special request,) in one case, each charge is usually composed as follows, viz:

1,390	lbs.	of coke.
675	"	spathic ore and brown hematite from Nassau.
675	"	brown iron ore.
150	"	granular ore.
350	"	lime (23.35 per cent of the ores).

For the production of one ton of gray pig were required:

3,850	lbs.	of coke.
3,700	"	ore.
860	"	lime.

The number of charges given in twenty-four hours is 55–60; the furnace is blown with three tuyeres, each of 2.64 inches in diameter, the nose pipes having a diameter of 2.4 inches, the temperature of the blast being from 400–450° F.; its pressure 1.5–2 lbs. per square inch.

In another instance, the charge is usually composed as follows:

1,300	lbs.	of ores, of a mixture similar to the one above, containing in the average, 42 per cent met. iron.
1,300	lbs.	of slags of the rolling mill.
900	"	lime.
1,600	"	coke.

For the production of one ton of white pig, are required 3,000 lbs. of coke.

For the production of one ton of gray pig, are required 3,600–4,000 lbs. of coke.

The furnace is blown with three tuyeres, allowing 4,310 cubic feet of blast air per one minute, which has a temperate of 250–300° C.

The display of the iron works of this group was rich, and very well organized. I mention that of the larger establishments.

1. THE ROLLING MILLS OF E. HOESCH & SONS, AT DUREN.

The firm owns the oldest rolling mills of Rhenish Prussia, which are situated at Lendersdorf, on the Cologne and Aix la Chapelle R. R., and also mills at Eschveiler, situated on the same line, and at Doitmund, Westphalia. The annual production amounts to 20,000 tons of wrought iron, of which about three quarters are rails.

The display comprised sets of wheels for railroad cars, made of steel, and polished steel plates. Very interesting, and showing clearly its construction, was a wheel of which all the different parts were loosely joined together, so as to give a clear idea of the mode of manufacturing.

2. THE MINING AND SMELTING COMPANY, "CONCORDIA."

The blast furnaces of this company were built in 1855; they are three in number, working ores from the vicinity, sparry ores from Siegen (fourth group), and red hematite from Nassau. There are eighty-five coking furnaces. The production of 1872 was 25,000 tons, or about twenty-five tons per twenty-four hours per stack. The product is, in the average, a white crystalline, seldom a gray or mottled pig. Of special interest in the display were pieces of pig, showing a considerable quantity of a glistening carburet of iron.

3. AASHENER IRON WORKS COMPANY,

At Rothe Erde, near Aix la Chapelle. This establishment, which is one of the most important and renowned, technic-

ally as well as commercially, throughout Middle Germany, has an old fame. It was founded in 1845, but since that time its accomplishments are enlarged by many new amplifications and modifications. It comprises at present rolling mills, wire drawings and Bessemer steel works. The production of 1872 was 39,500 tons of wrought iron and 1,000 tons of wire, both species of every possible description. The company employs about 1,000 workmen. Of excellent quality are especially such materials which are required in mining business, rails, crossings, girders, pillars, supports, etc., and wire used in woolen manufactories, for combs, etc.

There were displayed

10–12	different	Nos.	of bar iron.
20–24	"	"	nail rods.
5–6	"	"	for sieves.
4–6	"	"	of bundles of wire for needle manufacturing
5–6	"	"	for combs.

Besides telegraph wire, spiral springs, etc.

4. THE ROLLING MILLS OF ENGBERTH & CUNGER,

Near Aachen, with an apparatus of sixteen puddling, eleven balling furnaces and five pairs of rolls, the firm produced in 1872, 8,500 tons of wrought iron. A foundry and machine shop is connected with the mills, which produced 9,450 tons of wares. The product of the rolling mills is merchant iron, such for bridge building, also flat iron of the most different dimensions, axle trees, etc., samples of which were displayed at Vienna.

The enumeration of these few establishments of the second group may be sufficient.

THE THIRD GROUP.

Each of the numerous works of this group is supplied with coal for fuel which comes from the Ruhr coal bed. The Ruhr is a small tributary of the Lower Rhine, entering

this river at Ruhrort, not many miles above the boundaries between Prussia and the Netherlands. This coal field is marked on the map Fig. 12, and is a great deposit of bituminous coal, which is mined at hundreds of places. *

The ores used are of the most different character. To a great extent red and brown hematite from the Lahn, sparry ores from the territory of Siegen (of which I shall speak especially under the fourth group) and also Spanish ores, etc., are worked upon.

The Ruhr coal bed itself is very rich with veins of iron ores, but many of them are impure, and not suitable for the blast furnaces. This ore is mostly black band, besides which compact spathic ore and some argillaceous iron ore occur.

Of the three principal basins into which the Ruhr bed is subdivided, the southern and middle one contain some rich black band, which generally forms the upper layer of the coal, sometimes the lower; seldom it is intermitting the coal. There are about nine large mines worked upon this ore in the southern, numerous points of mining in the middle, but only two or three mines in the northern basin. Of the seven or eight veins of the blackband the thickness varies from ten to one hundred and forty inches, which are often interrupted by gangue masses.

Brown iron ore is found in the lower chalk, which forms the northern and eastern boundaries of the coal bed; it is mined at about four or five places.

South of the coal bed the different groups of the Devonian age form a mountainous country, termed the Sauerland, or Egge Mountains, Fig. 11 of the map. The upper Devonian formations, forming the northern edge of this mountain range, bear to a great extent red hematite, in large veins, very rich in metallic iron. The ores are very different in character, sometimes compact, hard and quartz bearing, sometimes soft, without quartz, but being calcareous. The

*A collection of specimens of coals from this and other beds of the provinces in question, made with the intention of testing their relative fitness for the iron industry, will be analyzed by Prof. Cox and brought into comparison with Indiana Block Coal, when they are received from Europe.

compact ores are prevalent; calc-spar, quartz and hornstone are often, iron pyrites and manganiferous ores sometimes its companions. Six or seven mines are worked upon it.

Of merely scattered occurrence are the other ores of the upper Devonian and the coal measures of the Carboniferous period (Fig. 10), which form the northern lining of the graywacke mountains. There are brown, red and argillaceous ores, partly in large veins, partly merely in pockets, forming in some way a transition to the ores of Fig. 12 of the map.

To the north and northwest of the coal bed there are very extensive beds of bog and swamp iron ores (granular brown oxides), Fig. 13. These ores always contain some phosphorus and often manganese; they are found in layers from a few to 12-18 inches thickness on the banks of all the tributaries of the Rhine and the river Ems, where they cover areas of square miles in continuous beds.

Lastly, the Weser Mountains and the Teutoberger Forest, Fig. 14, are ore bearing. These two mountain ranges, which have a parallel northwesterly stretching, are of the most variable geological formation. There are large deposits of ætites argillaceous iron nodules on the Weser, where this river forces its way through rocks of the Jurrassic formations (forming the "Porta Westphalica" of Roman remembrance). Granular iron ore, sometimes quite loose, sometimes agglutinated by calcareous or clayey paste, are found upon the formations of the Cretaceous period of these mountains. Ores are also found in the Lias, especially at the Southern outskirts of the Teutoberger Forest, forming veins of red iron ore, several feet in thickness. Finally the most northwestern foot hills of both ranges contain upon some coal beds of anthracite, of the magnesian limestone around the city of Osnabruck, brown iron ores in veins of from 6 to 24 feet extension, and more. Noteworthy is a mine, located about five miles from the city mentioned, which is worked upon a vein of 47 feet thickness.

I can not omit referring, that at the northern bank of the Weser Mountains, between the Porta Westphalica and the

city of Minden, about 3 miles distant from the former place, coal is mined; Wealden, the third division of the Jurassic formations, being the geological feature. The coal is very gaseous and mining extremely dangerous. Coke made of this coal is used in the blast furnaces which stand in the Porta Westphalica.

Analyses of ores of Fig. 10 of the map, I was unable to procure.

Analysis of ores of the deposits marked

FIG. 11.

The following analysis gives an average of the most important mines; the ores are worked upon to a great extent in the blast furnaces near Doitmund. (See below):

Peroxide of iron - -	47.71=Fe 33.39	
Silica - - - -	14.80	
Alumina - - -	4.00	
Lime - - - -	27.72	Carbonate of
Water - - - -	5.60	
	99.83	

Analyses of ores of the deposit marked

FIG. 12.

Compact spathic ore of the coal beds near Hattingen on the Ruhr:

Protoxide of iron - -	52.00=Fe 40.43
Magnesia - - -	2.29
Carbonic acid - - -	35.92
Peroxide of iron - -	2.75
Water - - - -	6.13
	99.09

The roasted ore contains 50 to 60 per cent. of metallic iron.

BLACKBAND.

Protoxide of iron - -	....	0.67	7.71
Carbonate of protoxide of iron	60.15	....	....
Magnesia - - -	....	1.21	2.22
Carbonate of Magnesia -	2.40	....	....
Lime - - - - -	....	6.06	4.64
Carbonate of lime - -	1.53	....	....
Carbonic acid - -	....	trace	0.76
Peroxide of iron - -	0.94	43.57	54.72
Peroxide of manganese -	....	1.88	0.94
Alumina - - -	6.64	11.91	4.04
Silica - - - - -	1.03	32.34	20.53
Water and organic matter -	4.96	0.44	1.42
Sulphuric acid - -	0.29	0.73	0.64
Phosphoric acid - -	....	0.61	0.72
Carbon - - -	21.27	1.20	2.94
	99.21	100.62	101.28
Metallic iron - -	46.77	31.20	44.17

The first of these analyses is of ore from a mine near Bochum; the ore is smelted in the furnaces of the Iron Works Company "New Scotland." The second and third analyses are of roasted ores, in which state they are used as an admixture in the blast furnaces at Horde. The samples represent the best ores of this kind found in Westphalia. *

Analyses of ores of the deposits marked

FIG. 13.

GRANULAR IRON ORES, FROM THE BANKS OF THE EMSHER, A TRIBUTARY OF THE RHINE.

Peroxide of iron - -	76.80	52.73
Silica, soluble - - -	1.00	6.33

*All the plates related to here and elsewhere can be found on the map.

Silica, insoluble - - -	6.52	27.39
Water, chemically combined -	13.78	11.26
Phosphoric acid - - -	1.42	1.90
Sulphuric acid - - -	0.30	0.19
	99.82	99.71
Metallic iron - - -	53.76	36.91

Analyses of ores which represent fair samples of the deposits described as

FIG. 14—RED IRON ORE FROM PORTA.

Peroxide of iron -	47.64=Fe 33.34
Silica - - -	16.66
Alumina - -	8.19
Lime - - -	3.42
Magnesia - -	2.76
Water - -	17.83 inclusive Carbonic acid
Phosphoric acid -	1.17
Sulphuric acid - -	2.01
	99.68

The ore is partly transferred into brown iron ore.

BROWN IRON ORE, FROM THE MAG. LIMESTONE NEAR OSNABRUCK.

Peroxide of iron - -	63.04=Fe 44.12
Peroxide of manganese -	3.75
Magnesia - - -	2.04
Silica - - -	18.79 soluble and insoluble
Water - - -	11.20 chemic. and hygrosp.
	98.82

ARGILLACEOUS IRON ORES (ÆTITES) FROM PORTA.

Peroxide of iron - -	48.79=Fe 34.15	
Carbonic acid - -	20.13	evaporated in calcining
Alumina - - -	9.43	
Silica - - -	14.56	
Magnesia - - -	2.76	
Lime - - -	3.05	
Sulphuric Acid - -	1.03	
	99.75	

The ore is analysed after having been calcined, from which reason the iron appears as peroxide.

SPATHIC ORE, FROM THE "OLDENDORF MINE," NEAR MINDEN.

Carbonate of protoxide of iron - -	71.45=Fe 44.35
Carbonate of protoxide of manganese	1.15
Carbonate of protoxide of magnesia -	9.09
Peroxide of iron - - -	11.95=Fe 8.36
Gangue matter - - - -	3.75
	97.39

The ore bears a crystalline appearance, but is very much impregnated and inpured by particles of slate.

I may add a few figures relative to the production of the ores mentioned above.

The total amount of ore mined in 1872 of the deposits shown in

Fig. 10 were -	25,600 tons	
Fig. 11 were - -	18,450 tons	(which is by no means in compliance with the extent of the beds.)
Fig. 12 were -	307,750 tons	(blackband, spathic, etc., ores.)
Fig. 13 were -	70,700 tons	
Fig. 14 were -	55,150 tons	
	477,650 tons	

In relation to the Spanish ores used by the iron masters of this group, I have to state that the mountain ranges of the Kingdom of Muria and Estremadura include some iron veins in the crystalline or elder sedimentary rocks, of from 3 to 10 feet thickness. Also the Pyrenees and the mountains of Biscay, Asturia and the north of Galicia, which are their prolongations, contain important mines of iron ores. They consist of deposits of red oxide of iron and sparry ores, as continuations of the more northern French sparry ores, which traverse the old red sandstone. There are also mines upon beds of hydrate of iron, subordinate to transition limestone.

Average analyses of the ores are the following:

RED HEMATITE.

Peroxide of iron - -	88.20=Fe 61.74
Silica - - - -	10.00
Alumina - - - -	0.55
Carbonate of lime - -	1.80
Loss - - - -	0.43
	100.98

BROWN HEMATITE.

Peroxide of iron -	75.05=Fe 52.53	70.10=Fe 49.07
Peroxide of manganese	1.45	3.65
Lime - - -	....	0.22
Magnesia - -	......	0.23
Alumina - -	....	6.33
Silica - - -	....	13.66
Clay - - -	12.50	....
Water - - -	11.00	....
Loss - - -	....	5.71
	100.00	99.90

SPARRY ORES.

Protoxide of iron - -	57.72=Fe 44.77	53.17=Fe 41.35
Protoxide of manganese	3.40	3.70
Lime - - -	1.90	2.30
Magnesia - - -	1.80	3.80
Silica - - -	0.08	7.60
Water and carbonic acid	35.78	29.71
	100.68	100.28

Of the Swedish and Norwegian ores also of course, only the best ones are imported for admixture.

The best iron mines of Norway are situated on the coasts of the gulf Christiana and on the side facing Jutland. The ores consist almost solely of black oxide of iron, forming beds of from 4 to 60 feet thick in the gneiss.

The best Swedish mines, of Wormeland, are also worked upon veins or beds of black oxide of iron, several yards thick, in rocks composed of hornblende, talcose and granite. The mines of Dannemora stand in the first rank of those of Sweden and even of Europe; there are also the immense, well known beds of brown iron ore, north of Stockholm, the Swedish capital, which are excellent for the contents of manganese. Some anlyses of the latter ores are shown in the following:

Peroxide of iron - -	65.57	70.38	61.84
Peroxide of manganese -	3.87	4.01	3.43
Lime - - - -	0.82	0.88	0.50
Magnesia - - -	0.15	0.21	0.06
Alumina - - -	5.08	1.23	5.19
Silica - - - -	7.15	9.18	11.33
Phosphoric acid - -	1.13	0.31	0.67
Sulphuric acid - -	trace	trace	0.43
Water, etc - - -	16.22	13.79	16.54
	99.99	99.99	99.99
Metallic iron - -	45.89	49.26	43.28

Of the African ore, such as calcareous brown hematites, from the northern coast, are imported which are reported to contain:

Peroxide of iron - -	57.25=Fe 40.07
Peroxide of manganese - -	3.50
Lime - - - -	10.00
Magnesia - - - -	2.00
Alumina - - - -	1.60
Clay - - - -	4.00
Water - - - -	21.00
	99.35

Before entering upon the discussion of the iron establishments having exhibited at Vienna, I give next a short general view of the blast furnaces, coking furnaces, hot air stoves, etc., as they are built at present, more or less, at all the iron works of this group. The first

BLAST FURNACES

in Rhenish Prussia and Westphalia, were built by Belgian engineers and workmen, years ago, but mostly during the period from 1852–1858, when the development of the iron industry had a great rise throughout the European Continent. The Belgian engineers built, of course, upon Belgian patterns, and following their steps, the German iron masters found it practicable to give their furnaces such measures as are contained in the table below. This table gives the dimensions of furnaces well known for the quality of their products and enumerated in the list of exhibitors at Vienna:

	Phœnix Iron Works.	Henrichshutte on the Ruhr	Horder Iron Works	Muhlhofen Iron Works.
HEIGHT.				
Total	53ft.	54ft.	52ft. 5in.	48ft. 6in.
Of the center of the tyeres above the bottom	2ft. 6in.	2ft. 5in.	2ft. 6in.	2ft. 6in.
Of the hearth	7ft. 6in.	7ft. 9½in.	5ft. 5in.	7ft.
Of the boshes above bott.	21ft. 6in.	17ft. 9½in.	16ft. 11in.	22ft.
DIAMETER.				
Of the mouth	7ft.	9f. 6in.	9ft.	10ft 6in.
Of the boshes	15ft. 6in.	15ft. 3in.	15ft. 4in.	15ft.
Of the hearth, above	4ft. 6in.	4ft.	2ft. 1in.	4ft.
Of the hearth, below	3ft.	2ft. 10in.	2ft. 1in.	3ft. 6in.

During a period following the time named, some engineers entered the manner of English iron masters, and this in such cases where the blackband is smelted. As an example I give the dimensions of a blast furnace, which is in blast a great many years for the production of gray pig:

Height, total	48 ft.
Height of the boshes above the bottom	10 ft. 8 in.
Height of the hearth	4 ft.
Diameter of the mouth	9 ft. 10 in.
Diameter of the boshes	15 ft. 9 in.
Diameter of the hearth	5 ft. 10 in.
Total cubical capacity.	5,650 cubic feet.

The upper outside casing of the furnaces is either of mason work (Belgian model) or of heavy sheet iron (English model); in the first case, octagonal, conical or pyramidal; in the latter, conical, but always corresponding with the inner lining of the stack, from which it is separated by intermediate shells.

The lower part of the outer casing is either a square of mason work, leaving the usual four openings on opposite sides, or the hearth itself stands entirely free and is cooled by water, the upper part being supported by pillars.

Of late, furnaces of Mr. F. Buttgenbach's patent, a well known iron master of the lower Rhine, are introduced. The first model of this gentleman's furnace was exhibited at the Paris Exhibition, 1867. The principle idea in constructing this furnace is, to have the hearth easily accessible from all sides; also the inner lining of the upper part, and to have the mason work entirely independent from the inner shell. Each part of the furnace is accessible while the same is in operation and constantly cooled by the free access of the atmosphere. This idea is executed in building up the hearth and boshes by themselves, as far as about 3½–4 feet below the greatest diameter, where a circular outer casing of mason's work, built around the hearth in a suitable distance, sets in so as to support the upper inner shaft. The latter is also exposed to the atmosphere and has no other coating but rings which sustain the shaft. A further peculiarity of the Buttgenbach furnace is a series of tuyeres, which are placed in two rows above the usual blowing tuyeres. Cold water is freely circulating through the same, so as to keep safe the hearth from burning out. These tuyeres are at the same time a ready means in case of necessity to supply the hearth at such places with blast air where obstructions should appear. The latest peculiarity of the Buttgenbach system is, that the platform is supported by pillars which serve as flues for the waste gases. These pillars are supported by a sheet iron vessel, of a form of which I shall speak below, and which is placed on the top of the mason work, which is put around the lower part of the furnace. Several years experience has proved, that there is no fear to be entertained in cooling the furnace too much and thus producing irregularities in its behavior.

In either of the foregoing cases, the hearth, bottom, breast and dam of the blast furnaces in Rhenish Prussia and Westphalia are made of mill stone grit from Marchin on Huy, in Belgium. This valuable material is a coarse conglomerate, composed of white quartz pieces, conglomerated by a whitish quartz mass. Sometimes there are gray or brown spots in it, created by the presence of iron; small spots or

thin veins are not considered noxious; large ones are. These rocks occur in layers of from two and a half to three feet thickness. In cutting the stones for use in the furnaces, it is found necessary that the sides of the hearth stand vertically to the layers. The mass is extremely hard and very difficult to be worked; it bursts into pieces easily when suddenly brought into fire. For this reason a new hearth is always fitted out with a coat of fire bricks, so as not to allow the fire to operate directly upon it when the furnace is blowing in. One cubic foot (English) of this mass weighs about 155 pounds, and the ready made stones for one furnace (bottom, breast, dam and hearth) cost about $1,500.

The ring wall is generally made either of Garnkirk (near Glasgow, Scotland) or Belgian fire bricks. There are some deposits of fire clay on the banks of the Rhine, near Bonn and Coblentz, and in Hessia, but its qualities are not considered good for the purpose in question. For the building up of these bricks, which are bought in the average at seventy cents per one hundred pounds, at the establishment, clay from Dudley, Stafford county, England, is often used, which sells at three to eight dollars per ton, according to the quality. Clay from Andenne, near Namur, Belgium, where it is found in small beds in the transition rocks, is also often used. As to the

TUYERES AND BLOWING ENGINES,

The furnaces are blown with three, five and six tuyeres. Those of Belgian construction generally have one tuyere on opposite sides, and one in the posterior wall; sometimes there are two at each side, the direction being somewhat declined from the center of the furnace, so as to force the blast in a kind of revolving way into the hearth. Where the hearth stands free, the tuyeres are placed around in equal intermediate distances. The diameter of the nose pipes varies, according to the working of the furnace, from one and a half to two and a half and three inches; the pressure also from one and a half to three lbs. per square inch. The

quantity of blast air blown into the furnace is variable from 2,700 to 4,500 cubic feet per one minute, the temperature from 250 to 400° C. Two furnaces mostly have one blowing engine of 100–150 horse power, or two of seventy-five to eighty horse power each. The engines are either beam blowing engines, or horizontal ones, some of them with slide valves, others with flap valves. At all the different establishments one receiver or regulator of the blast supplies all the furnaces, whatever may be their number. For with the increase of its cubical capacity the uniformity of the stream of the blast is facilitated.

The furnace of English pattern which I mentioned on page 39 is blown with seven tuyeres of from 2.5 to 3.25 inches diameter; the pressure of the blast air is 2.2–3 lbs. per square inch, its temperature 300° C. The daily production being twenty-five to thirty tons, and the amount of fuel (coke) required per one ton of pig being 1.65 tons, the quantity of blast air necessary for the production of one ton pigs is calculated to 204,762 cubic feet, or 3,530–4,300 cubic feet per one minute.

Each blast furnace has generally now three sets of

HOT AIR STOVES,

Which communicate with one line of conducting pipes leading to the blast furnaces. Thus in case of repairs required in one set the other two may be kept in full activity, capable of supplying an abundance of heat to the blast. Of course they are of different construction, but the following are such as are mostly used:

1. Apparatus with syphon pipes, flattened laterally or round, as in some cases. A system of such pipes is set in a kind of oven, from which the flame is taken out at the top of it; but it then again descends before it reaches the chimney, entering it nearly at the height of the fire grate. By this manner the pipes are kept in a bath of ignited air, and not exposed to the corroding influence of a current flame. There are usually 36 pipes in two sets, arranged alongside, which

(the pipes) are six by two and a half inches wide (inside), and have a length of four feet. Under each set of pipes is a grate eighteen inches wide. The distance between the pipes of one set is, from center to center, eight inches, and of the center of one set to the center of the other three feet six inches. The flues, nine in number, are six inches wide, and terminate in a chimney twenty feet high and sixteen inches wide.

2. To prevent the alteration of form to which the arched pipes are subject, at a high temperature, this system is somewhat changed in the manner that the arch is cut in two, the upper end of the pipes enlarged, (so as to represent the form of the butt end of a pistol,) and the pipes separated by means of an interior wall. The blast goes up and down in each pipe, there being an opening in the interior wall at its upper end. Generally there are fifty-six pipes, or 28 on opposite sides, in each oven of from twelve to fourteen feet length. The surface exposed to the flame is about 2,500 square feet.

3. Another apparatus has horizontal pipes, their section being a parallelogram, to give more heating surface and also more depth of pipe, so as to make it stronger and less liable to bend by its own weight when softened by the red heat. From twelve to thirty of such pipes are placed in three to five rows, one above the other. Each pipe has a length from five to ten feet; the greatest diameter is ten to fourteen inches, the smaller about three inches, inside. The pipes are placed vertically in distances from five to ten inches between the rows.

4. Of late there are apparatuses built in which the pipes are free hanging, supported from above. This system involves two advantages: first, it is very easy to exchange defective pipes; and secondly, all the heat is entirely utilized, and in the most effective manner. The pipes are eighteen to twenty inches wide and divided by an interior wall in two rooms, so as to force the blast, which comes from the main pipe placed on the top of the oven, to go first

down and then up. The length of the pipes is about twelve to thirteen feet. Thirty-six pipes are placed in two sets, eighteen in each row, in one oven.

The next apparatus in order to mention are the

COKING FURNACES.

1. Francois' or Renroth's system. The furnaces of this system are built in a shape that their bottom forms a parallelogram, the dimensions being about the following: the floor is of as many square feet as cwt. of coal are intended to charge the furnace once. The proportion of the width to the length is, 1:6 or 1:7, the length not averaging twenty-five feet. The vertical side walls are closed by an arch, the height from the floor to the center of it being about twice the width. The width is generally from thirty-eight to forty inches. The side walls are five inches thick, the flues between the walls also five inches wide; the bottom and walls are hollow, for the purpose of allowing the gases to heat the whole apparatus; thirty and more of such furnaces are often combined in one set. The arches closing the furnaces are seven to eight inches thick. The central flue, into which the gases flow after having circulated around the furnaces, and which terminates in a chimney stack, is of a width of about one-twentieth of the square contents of the furnaces. The latter are filled from above with five to six tons each, which are ready coked in forty-eight to sixty hours; the yielding is about sixty to sixty-two per cent.; the cost of coking is ten to twelve cents per 100 pounds. This system is generally now followed by all the iron establishments in Westphalia, while in Rhenish Prussia, also,

2. Appolt's system is followed. In this system the coal is coked in smaller quantities than in any other furnace. They are apt to produce a superior quality of coke, which has a compact, glistening appearance. Coal

From Saarbrucken yields in such furnace.........68 per cent.
From Liege yields in such furnace............80–82 per cent.
From Ruhr beds yields in such furnace......75–78 per cent.

Nearly all the iron masters are now using the

WASTE GASES

For heating the boilers of the steam engines, or the hot air stoves. Some years ago there existed a great waste of fuel in heating the cold blast, and while one sought the advanages of hot blast, the expenses for providing it greatly outbalanced the benefits or economy which it was intended to create. Why not apply for this purpose the gases already created in the furnace and generally wasted? This ques tion met for a long time with great opposition, and this because the method of gaining the gases had always been conducted in a decidedly wrong manner. All those methods which withdraw the gases from below the mouth of the furnace, are always injuring the smelting process because they hurry the same. In defining the dimensions of a blast furnace (heights and widths) it was found necessary—first by experience, and afterwards by theoretical confirmation—that the masses intended to be subdued to the smelting process must remain a certain time in the furnace. The gases, created by combustion, decomposition and composition, must remain long enough in contact with the metalliferous ingredients, in order to execute that portion of the process which is termed the preparation and reduction. Arrangements extracting the gases before they have fulfilled this effect are wrong, as they damage the whole operation considerably. Only after having had the necessary effect they can be collected without doing any injury. This principle is fulfilled in a prompt manner in the apparatus of Mr. Langen, general superintendent of the Lieg-Rhine Mining and Smelting Co. whose apparatus can be found at present affixed to a great number of the blast furnaces of Rhenish Prussia and Westphalia. The apparatus itself is very simple, but this is one of its prerogatives,

because all other more complicated arrangements cannot endure very well the change of temperature which often takes place at the mouth of the furnace. Mr. Langen's arrangements are the following: Upon the mouth of the furnace there is placed a truncated cone of cast iron; the smaller diameter (which corresponds with the one of the mouth) is placed below, and the height of the cone is to be calculated from the amount of materials i. e. coal, or ores and flux, intended to charge the furnace once.

Next to this cone, and fitting into its smaller diameter, comes a cylinder which has about twice the height of the cone, and has a two-fold design:

Firstly, to charge the furnace with the materials; and

Secondly, to receive the gases after they escape off the surface of the masses, and conduct the same, by way of connecting tubes, to the places where they may be required for economical use.

To fulfill the first object, the cylinder is covered at its top, leaving only the center to about three feet wide open. The edge of this opening is mounted with an angle iron pointing downwards, so as to go in the upward curved lower end of a suspended tube. The thus made little room is filled with water, to prevent the gases from escaping at this place. Suspended in chains, the cylinder can easily be moved up and down by means of levers mounted on pillars and a windlass affixed to the outer end of the levers. After filling the cone, or, properly speaking, the open room between the cone and cylinder, the latter one is wound up, and the coke, or ores and lime, slope down into the furnace without any obstacle. And this is done in a way very advantageous to the whole process: the heavier ore will fall nearer to the circumference of the furnace, while the lighter coke goes more to the center, and it is known that the greater amount of the gases takes its way along the sides of the furnace. Thus this method of charging has the great advantage of bringing the ores in more intimate contact with the gases.

To fulfill the second object, the gases take their way out of the mouth through the cylinder into a tube suspended by the same arrangement of pillars which support the levers mentioned, and thence, by means of following flues, next to a cleaning apparatus. Of course, the first receiving tube is mounted with valves for the regulating of the flowing off of the gases, as well as for the cause of safety; for explosions, created by the mixture of the gases with air, are inevitable. The cleaning apparatus is a vessel or tube, open on one side to a certain height and provided there with an addition which prevents water, filling the bottom of the vessel so as to close the opening, from flowing off. Here the gases deposit all the dust, or fine ore and coke particles carried off from the furnace, while a great part of the water, which is always suspended in the gases as vapor, is condensed. At the same time, this apparatus acts as a great valve, because the column of water can easily be thrown out by any event of an explosion, thus paralyzing its injurious effects. From this cleaning place, the gases, in a merely cleaned state, are conducted to the steam boilers, or hot air stoves.

The pressure of the gases of a furnace which is in good behavior, is not more than 0.2–0.33 lbs. per square inch; the temperature about 75–80° Celsius.

The gases of one furnace are considered to be sufficient for two steam boilers of an engine of 70–75 horse power, and one hot air stove.

In all instances, the gases should first be used under steam boilers, and only in the second place for the heating of the blast air. Considered that the effect produced by the gases in either case is a benefit to the management in general, it should be theoretically the same, whether used for the producing of steam or hot air. But, practically, there is a difference. The quantity of blast air required in a furnace, is proportioned to the amount of gases given off by the furnace but there is no such relation between this amount and the temperature of the blast. If there occurs any misbehavior of the furnace a higher temperature is mostly

always a remedy against it. Exactly in such cases the amount of gases diminishes on account of the growing coolness of the furnace, and for this reason it is safe not to depend upon the gases for the heating of the blast, but to have fire places for direct firing attached to each hot air stove.

Finally, I must add a few remarks to the

ROASTING OF THE ORES.

To enumerate all the different kinds of roast-kilns would go beyond the limits of this paper. Most all of the roasting process is executed in furnaces, sometimes between little walls, (rost-stadeln, in German,) or in heaps in the open air. In the two latter cases the fuel is always in immediate contact with the ore which is intended to be roasted, while in the former, this contact may or may not, as in furnaces with gas firing, take place.

The roasting of the blackband is always done in heaps. Alternate beds of fuel and ore, which is used in medium sized lumps, are formed, the fire kindled at the lower part and the combustion so conducted as to be slow and to let the whole mass be equally penetrated by heat. The heat itself is to be regulated so as not to melt or vitrify the ores, which is done by covering with earth where too much activity is displayed, or in piercing holes to give air where it is imperfectly developed.

Such ores which are very fine are often roasted in stadeln. Three walls surround the roasting place, with openings around to allow the successive admittance of air to the fire. There are also little chimneys inside of the walls, corresponding with openings and flues in the bottom, in order to create draughts of air in the surrounding parts.

Little can be said as to the consumption of fuel in these two cases, because it varies with the variety of the ore, some blackband burning even by itself, without any admixture of fuel.

The furnaces employed to roast the spathic ores differ

much. The requirement in this case is the disengaging of combined water and carbonic acid, and the decomposition of sulphuret. No ores in the form of small, little pieces, or powder, are roasted in kilns; they can only be used in the shape of lumps. To extract the decomposited sulphurets, roasted spathic ores are always kept for months exposed to the influence of the atmosphere.

In enumerating the iron works based upon the use of the materials and apparatus described above, and which were represented at Vienna, I shall follow a geographical line, commencing on the banks of the lower Rhine, going eastward along the line of Cologne-Minden R. R. as far as Hamm, Westphalia, and departing north or southwards from this road, as far as necessity requires.

1. SUMMER, BLOSER & CO.,

Proprietors of the Neusser Iron Works, at Neuss, on the Rhine, displaying collections of ores and pig iron, also a model of Mr. F. Buttgenbach's blast furnace. This gentleman is general superintendent of the company. The establishment, situated in close vicinity to the river and two important railroads, is enabled to smelt the choicest ores, which can be conducted thither at very low rates. The collection of ores exhibited was therefore remarkable for its foreign constituents, especially of Spanish ores, which are melted by the company for several years. The production is about thirty tons per twenty-four hours per furnace. The quality of the iron is regulated by the commissions ordered.

2. PRUSSIAN MINING AND SMELTING CO.,

At Dusseldorf. The company owns three extensive coal mines and the iron works, "Vulcan," situated near Duisberg on the Rhine. At "Vulcan" there are four blast furnaces which are blown upon foundry pig, white, glistening iron and spiegeleisen, just as demands for any of these qualities require. Situated on the right bank of the Rhine, and being the terminus of several important railroads, this

establishment, like others of the vicinity, is enabled to smelt the most different ores, from near by or from remote countries. At Vienna was displayed a collection of twenty different ores, of the most different origin, and a very interesting illustration of five different methods of working was given, which are followed in smelting the ores, and producing a quality of iron satisfactorily to the demands of the customers.

3. Mining and smelting company,

"FREDERICK WILHELM IRON WORKS,"

At Mulheim on the Ruhr, which not only owns mines and blast furnaces, but also a very large foundry and machine shops. The production of the company was, in 1872, 8,150 tons of cast iron, ready made machines of any description, water tubes and gas pipes. The four blast furnaces produce about twenty-five tons of gray pig each per twenty-four hours.

4. Mining and smelting company,

PHENIX,

At Saar, near Ruhrort on the Rhine. The company owns a very extensive stock of apparatus for the fabrication of pig and wrought iron, ore and coal mines.

The company produced, in 1872, from two mines near Berge Borbeck, on the C. M. R. R.,* with seven hundred workmen, 150,000 tons of coal; from twenty-eight mines were produced, by 1,000 miners, also 150,000 tons of ores. Besides these, the company smelts, to a great extent, foreign ores, such as Spanish, and others, for which reason the display of ores was divided in two classes, i. e., ores from their own country and foreign ores.

The ores are smelted at three different places, viz:

At Saar, near Ruhrort, in six blast furnaces.

At Borbeck, on the C. & M. R. R., in four blast furnaces.

* Cologne-Minden R. R. ** Bergisch Markisch R. R. (See Map.)

At Kupferdreh, on the B. & M. R. R., in two blast furnaces.

With such a variety of ores and furnaces, the company is, of course, enabled to produce any quality of iron wanted, from gray pig No. I, to spiegeleisen. While the blast furnaces at Saar and Borbeck mostly work for the requirements of their own rolling mills, those at Kupferdreh work for dealing with other firms. The product of the latter furnaces is especially well famed for its excellent qualities as foundry pig.

The rolling mills at Saar mostly produce rails. In rolling mills at Eschweiler, near Aix la Chapelle, (strictly belonging to the second group of this paper,) owned also by the company, rails, T and ⎯ double T irons for building purposes, axle trees, angle iron, etc., are produced.

Of late, there is also a Bessemer Steel works in operation at Saar. The total production of the company amounted, in 1872, to:

At Saar -	38,450 tons of pig iron;	31,150 tons of rails
At Borbeck	17,850 tons of pig iron.	
At Eschweiler		10,200 tons of rails. 7,800 tons mrch't iron.
At Kupferdreh (not given).		
Total -	- 56,300 tons.	49,150 tons.

5. Mining and Smelting Company

"GUTE HOFFNUNG IRON WORKS"

at Herkerade, near Oberhausen, on the C. M. R. R. This Company was formed during the present year (1873) of the old firm, Jacobi, Haniel & Huyssen, established in 1808, and owns:

First. The iron works at Oberhausen, comprising ten blast furnaces and very extensive rolling mills, producing rails, merchant and sheet iron.

Second. A Bessemer Steel Work and rolling mills, for the manufacturing of steel rails, at New Oberhausen.

Third. Machine shops on a grand scale at Herkerade, and an extensive foundry at the same place.

Fourth. A ship yard for the construction of iron vessels, steamers, gunboats, etc., for navigation on the Rhine and seacoast navigation.

These four establishments are worked with a force of about 8,000 men, producing, in the average, 75,000 tons annually of ready made iron of any quality or form.

The display of the firm consisted of a large collection of raw materials and products, and some monster pieces; a U iron, 46 feet long, and a piece of flat iron 55.75 feet long and twisted, cold, to a spiral.

6. Iron Works Company

"STYRUM,"

near Oberhausen. The rolling mills of this Company, established in 1857, and containing at present 40 puddling and 20 balling furnaces and 11 sets of rolls, produced, in 1872, 15,000 tons of bar, flat and facing iron, with 650 workmen.

Specimens of every kind of products were displayed; flat iron of 3.25 ft. width and boiler plates 8.25 ft. wide, were noteworthy.

7. I mention here the

"HEINRICH'S IRON WORKS"

at Hattingen on the Ruhr, which were not represented at Vienna, but which may find a place in this report because the blast furnaces of this establishment are especially worked upon blackband and spathic ores of the Ruhr coal beds. These ores are melted here to a greater extent than at any other iron work to be mentioned. The establishment is owned by the Berlin Discount Company, who also owns

extensive works and mines in Upper Silesia. It contains four blast furnaces which are situated on the banks of the Ruhr, in the closest vicinity of the ore and coal mines, thus affording a very cheap transportation of the raw materials. The blast furnaces are constructed on a large scale, after such dimensions which are found to be the best for the melting of blackband. The belly is nearly cylindrical and a wide hearth is provided, both on account of the easy fusibleness of the ores and for the quicker slope of the charges. The accurate dimensions were given above in the table of heights and widths of blast furnaces.

The blackband used is always roasted, either in heaps or stadeln; some mines contain so much of organic matter that they do not require any admixture of fuel. Heaps of 50 ft. length, 12-15 ft. wide and about 8-10 feet high require from two to three months time for roasting. The roasted ores contain up to 55 per cent. of metallic iron, the richest ores bearing a dark blue color, the poorer ones a light red one. These latter ores would give a small yielding in the furnaces, but they are excellent for admixing to the spathic ores because they always contain some clayey matter.

The compact spathic ores, or carbonate of iron, which are used here, has no relations externally with the sparry variety. (See 4th group).

It comprehends most ot the clay iron stones, and particularly that which occurs in flattened masses of various size among the coal beds. The color is dark gray, its fracture coarse grained. The coal used is very bituminous and yields a porous, but strong coke. The coal is brought direct from the mine to the coking furnaces, for it is found that its qualities are deteriorated by exposing it for a longer time to the influence of the atmosphere, giving an easy crumbling coke. The coking furnaces are of Francois' system, 6 ft. wide, 22 ft. long, each charged with 120 Scheffel (220 bushel) of coal, which are ready coked in 28-30 hours. The gases of these furnaces are used for heating the steam boilers, which are placed on their top. The yielding of coke is about 55.62 per cent. by weight.

For flux, limestone is used, containing about 98 per cent. of carbonate of lime. The daily production per furnace is about 30 tons; the yielding of the ores in the average 38 per per cent., of the mixture (inclus. lime) 28.5-30 per cent.

The charges are usually composed as follows:

3,100 lbs. of spathic ore,
1,390 lbs. of blackband,
1,570 lbs. of lime,
2,400 lbs. of coke,

while for the production of one ton of pig iron are afforded:

3,606 lbs. of spathic ore,
1,606 lbs. of blackband,
1,814 lbs. of lime,
2,792 lbs. of coke.

The temperature of the blast air is about 300° C., its pressure 2.5 lbs. per square inch. There are three tuyeres, those on opposite sides of 4.5 inches, the one in the posterior wall of 3.25 inches diameter, thus giving an amount of 3,710 cubic feet blast air per one minute.

The slag is strong, light gray and white, only the edges are glassy and always showing a superamount of bases (lime). In cases where its stoney quality turns over into a glassy one, the iron changes from gray into white, but the addition of a few per cent. of lime will always restore the proper behavior of the furnace. The quantity of slag per 100 lbs. of iron is found to be 120 pounds.

The iron produced in the furnaces is worked in a rolling mill, and a foundry and machine shop also belonging to the Company. The latter three establishments work for the demands of the numerous coal mines in the neighborhood.

8. The

"BOCHUMER STEEL WORKS"

at Bochum, on the C. & M. R. R. This establishment is,

besides the one of Mr. Kruppe, the largest steel work of Westphalia, and perhaps of Germany; it had a beginning upon a very small scale, in the year 1843. From that time until 1854 it was the property of Messrs. Meyers and Kuhne, when it came into the possession of its present owners, a stock company. The firm has now coal mines near the city named, likewise iron mines in the territories of Siegen and Nassau, blast furnaces at Mulheim on the Rhine, and the well famed "Cast Steel Works" at Bochum.

It is a principal peculiarity of this latter establishment to produce any article required for the market of cast steel, like others do of cast iron. The mode of working is a secret, which was first introduced by the previous owner, Mr. Meyer, now the general superintendent of the company. The accuracy of the different articles now produced is really astonishing, and of such an accomplishment that no further working upon the cast pieces, by hammer or file, is required.

There were a great many useful things of this kind displayed at Vienna. Bells, springs, ship propellers—one of six tons weight—wheels for railroad cars, and other numerous products, manifesting the well deserved fame of the company.

The production of 1872 amounted to 48,000 tons ready made cast steel articles, including 7,200 tons of car wheels. 5,000 workmen were employed for the fabrication.

The steel works contain sixteen puddling, nine balling and ninety-two re-heating furnaces, twenty-seven melting furnaces, seven Bessemer converters and steam hammers, and numerous forges.

9. The "New Steel Works Co.," (Daelen, Schreiber & Co.,) at Bochum, established in 1869, own a first class Bessemer steel work, which produced, with three hundred workmen, four cupola furnaces, 2 converters and seven regenerative furnaces, in 1872, 9,000 tons of tires for railroad cars, axle trees and parts of machinery.

10. Rolling mills of

SCHULZ, KNAUDT & CO.,

At Essen, established in 1856, produced, in 1872, with four hundred workmen, fourteen puddling, six balling and four re-heating furraces, rolls, etc., 7,000 tons of sheet iron, boiler plates, such for locomotives and others of heavy weight.

11. Rolling Mills of

GRILLO, FUNCKE & CO.,

At Gelsenkirchen, near Essen, established in 1866, produced in 1872, with four hundred workmen, in seventeen puddling, 8 balling furnaces, and the corresponding sets of rolls, 9,500 tons, nearly all boiler plates, and others.

12. FREDERICK KRUPPS'

Steel work, at Essen, is of wide-world fame and often described already. Established in 1810, the very extensive establishment comprises at present four coal mines, four hundred and fourteen ore mines, five iron works with twenty blast furnaces, nine hundred and twenty furnaces of every description for the producing of cast steel, and steam engines of a total of 10,000 horse power, not including seventy one steam hammers.

The display at Vienna was brilliant, comprising some thirteen different light and heavy cannons, machines, wheels, axles, rails, tires, and a cast steel block of 52.5 tons weight, which was founded with the contents of 1,800 crucibles, containing each sixty pounds of steel, and afterwards forged under a giant steam hammer to an octagonal of the weight stated. Series of fine fractures of steel, collections of ores, coal and pig iron gave also an idea of the wealth and accomplishment of the firm.

13. The iron works of the mining and smelting company,

"HORDE,"

Near Doitmund. The origin of these works must be traced back to the year 1839, when they first were erected by Mr. Piepenstock. The company own at present coal and iron ore mines upon blackband, at Horde and Hasslinghausen, upon sparry ores and brown hematite in the Hartz mountains. The mining business of the company alone gives employment to about 1,500 miners, who produced, in 1872, 185,000 tons of coal, and 36,500 tons of ore.

Not having spoken yet of the ores of the Hartz mountains, I give here the following short remarks:

The Hartz, a hilly country situated W. S. W. from the old city of Magdeburg, on the Elbe, covers an area of about 43 miles in length, from S. E. to N. W., and 18 miles in breadth. The common rock of this range is graywacke, which is covered with a transition limestone. The granite supports all this system of rocks, while at certain points trap and hornstone appear. Silver and copper are the principle metals found in the mountainous country, but besides this there are a great many mines of iron in different parts of the Hartz, the principal ores being spathic ore and red and brown hematite, which occur in veins, beds or masses.

At Horde there are 8 blast furnaces, rolling mills with 82 puddling, 56 balling and 16 re-heating furnaces, 4 cupola furnaces, 164 coking furnaces and two Bessemer steel works with 8 converters, besides the other necessary apparatus.

The blast furnaces produce about 75,000 tons of pigs annually, and it is said that they consume per ton of iron:

4,640 lbs. of ores.
1,250 lbs. of lime.
2,500 lbs. of coke.

The production of the rolling mills and the steel works is given as 60,000 tons per annum.

The display at Vienna did show that the Company does not cultivate a special branch of manufacturing, for mostly every kind of wrought iron was exhibited. Rails for railroads and mines, merchant iron of any description, heavy blocks of steel, stringers, tires, girders, bar, flat and square iron, nail rods, etc., etc., were displayed, and the collections completed by full descriptions and drawings of the apparatus employed, and tabular statements of the consumption of raw materials used and the products gained. There was a tire, unadjusted, horizontally suspended with a center needle revolving, showing the accuracy of the work, etc.

14. The Iron Works of the

"WESTPHALIAN UNION,"

comprising four different establishments:

A. Department Hanem, formerly Cosack & Co., comprising large rolling mills, which were established in 1853, and producing annually 14,000 tons of wrought iron. The work consists of 30 puddling and 9 balling furnaces, 4 steam hammers, 5 sets of rolls, a foundry, a machine shop, a manufactory for galvanized iron, another for the fabrication of refractory bricks, etc.

B. Department Wachrodt, comprising rolling mills with 21 puddling and 7 balling furnaces, and 7 sets of rolls, producing annually 12,000 tons.

C. Department Lippstadt, comprising a rolling mill with 10 puddling and 2 balling furnaces, and 3 sets of rolls; also, several charcoal blast furnaces and a wire drawing plant; the mills produce about 6,500 tons per annum.

D. Department Verdohl, comprising a rolling mill with 16 puddling, 3 balling furnces, and three sets of rolls; also, 2 blast furnaces and a wire drawing plant. The annual production amounts to 9,500 tons.

The products of the Company have a well founded fame, and the display of the different articles, especially that of wire, was an attractive one.

15. HOBRUKER, HERBES & WITTE,

at Hamm, established in 1856, produced in 1872 with 950 workmen in 30 puddling, 6 balling furnaces, 6 sets of rolls and 424 draw-benches and 60 nail-making machines, 13,500 tons of wire and 3,750 tons of wire nails. The telegraph wire produced by this firm is excellent. As a proof of the good quality of the wire produced see the products of Mr. Newfeld, of Doitmund, who is the manufacturer of both iron and steel ropes.

16. "STEEL WORKS" AT WITTEN

on the Ruhr, established 1854, comprising a cast-steel work, forges, etc., and producing especially gun barrels, sabres, cannons, pistons for steam engines, and weapons of any kind, displayed in a neat collection.

17. Mining and Smelting Company

"NEW OEGE,"

near Limburg on the Lenne, a tributary of the Ruhr, established in 1830, producing in two blast furnaces excellent spiegeleisen for the Bessemer process, and in a rolling mill with 24 puddling and 10 re-heating furnaces annually about 13,850 tons pig-metal, 600 tons cast iron and 8,900 tons of wrought iron. Number of workingmen employed, 560. A specialty of the Company are rolls, switches, pulleys, etc., of hard cast.

18. Rolling Mills

"STEINHAUSER HULTE,"

at Witten on the Ruhr, established in 1857, produced in 1872 with 27 puddling, 12 balling, 2 re-heating furnaces and the corresponding number of rolls, 22,550 tons of rails and angle iron. There is also of late a Bessemer Steel Work established by this Company.

19. Steel Works of

ASBECK, OSTHAUS & CO.,

at Hagen, especially manufacturing springs, established in 1853, produced in 1872 with 400 workmen in 26 puddling, 3 re-heating furnaces and several sets of furnaces for cementation, 8,850 tons of bar steel.

20. Steel Works of

SODING & HALBACH,

established 1783, produced in 1872, in 38 furnaces, 5,750 tons of steel in bars, and especially anvils. The establishment is located at Hagen.

There still remains a large number of exhibitors of this group to be enumerated, but it would be tiresome and uninteresting to the readers in this country to name them all, because it would be only a recapitulation of their products, etc. Be it sufficient to say, that the different displays were fine and well adapted to give an impressive idea of the skill and industry of Westphalia's numerous iron masters.

I must give, however, the short description of the two great iron works which are situated on Wesphalia's outpost, near Osnabruck, in the province Hannover, on the western foot hills of the Teutoburger Forest.

1. IRON AND STEEL WORKS, NEAR OSNABRUCK.

They were established in 1869, and produced with 900 workmen, in 1872, 21,750 tons of steel, mostly from pig iron of the iron works of the vicinity. There was a complete display of the finest steel, of fractures showing the quality of the raw materials and half ready made products, of rails, axle trees, tires, angle iron, etc., and with others a rail wound into a spiral which could be easily set into oscillation, showing the perfectness of the product.

2. Mining and Smelting, Company

"GEORGE AND MARIE,"

at Oesede, near Osnabruck. This Company, which is to be accounted for as a producer of first class pig iron, as well as for the many inventions and improvements realized by their worthy engineers, was established in 1856. The Company own at present three great coal mines upon anthracite and partly bituminous coal, and iron mines upon ores of the magnesián limestone, from which in 1872 not less than 225,000 tons were produced. These very good natured ores are melted in six large furnaces, of which five are always in full working condition. Extensive machine shops and a large foundry are branches of the iron work, and the total establishment represents one of the greatest, best arranged and best managed iron works of Germany. The production of pigs amounted to 75,500 tons, of which about 70 per cent. are used for Bessemer steel producing, while the remaining part of the production is sold to rolling mills at high prices, on account of the excellent quality of the iron. It is an invention of Mr. Lurmann, the manager of the blast furnaces, to transform the slag resulting from the blast furnaces into a fine, hairy, woolen-like mass, which is most usefully employed in enveloping steam pipes, etc., for preservation against cooling.

Messrs. N. H. Meyers & Co., at Osnabruck, produce also of the slag artificial stones for sidewalks, floors, steps, imposing stones, etc., etc., using metallic oxides for coloring, which gives the work finish and durability.

The limits of this paper will not permit a full description of this very interesting establishment, but I must state, that it is unwillingly in fact, I omit further particulars, because they really deserve attention.

THE FOURTH GROUP.

The transition lands which form in the Northwest of Germany a pretty extensive range of hills, include several famous deposits of iron ores (besides zinc, lead and copper.)

The principal mining points are on the right bank of the Rhine and on its tributary the river Lahn, in the territories of Nassau and Berg. Veins of hydrate of iron or brown hematite are explored at a great many points along with veins, or properly speaking masses of sparry ores and beds of red oxide of iron. The Old Red Sandstone of the territory of Siegen bears a great number of powerful veins of these ores which accumulate sometimes to incredible masses. The center of the ore bearing formation has an extent of at least 45 miles length from N. to S. W., while the field covers an area of not less than 24 miles width.

There are three principal lodes which can be distinctly traced, having in the average a power of from 7 to 28 feet, but culminating at Stahlberg, near Musen, to a grandious mass of the finest sparry ore of 80 feet thickness. These three lodes are in the average sparry ore, but besides this, excellent brown iron ore, formed by decomposition of the former, is found—both species being manganiferous. These lodes are marked on the map Fig. 9.

Superficial deposits of granular brown oxide, in pieces nearly round, much varying in size and agglutinated by a calcareous and argillaceous paste, occur in extended masses northwestward of the sparry iron region; they are marked Fig. 8.

The tertiary formations which cover the country north of the Siebengebirge and the adjacent hills, contain rich deposits of clay iron stones (Fig. 7), partly of excellent quality. They are mined on the northern flanks of the "Hardt" tableland, which outlines the Siebengebirge (a range with seven prominent peaks) northwards.

Noteworthy above all the latter deposits—the sparry ores excepted—are the abundant and beautiful veins of hydrate of iron, and red hematite of the territory of Wetzlar and those on the banks of the Sayn and Lahn, Fig. 6. As to their geological formation I may add, that they are entirely of the same position as those ores described under Fig. 11, and are in fact their continued lodes. These ores mostly occur in moulds, near to the surface. Red iron ores are

predominant, hard and compact ones—containing some quartz—as well as some soft ones, which are free from quartz, but calcareous.

ANALYSES OF ORES FROM THE TERRITORY OF SIEGEN.

FIG. 9.

A. Sparry Ores.

	1.	2.	3.	4.	5.
Protoxide of iron	44.9	46.3	46.97	47.10	48.83
Protoxide of manganese	10.3	9.1	7.56	8.19	10.80
Magnesia	1.6	4.5	2.22	2.45	1.41
Lime	1.0	.....	0.46	0.34	0.41
Carbonic acid	37.0	38.4	36.15	36.45	38.38
Gangue mass	4.2	1.4	5.74	4.60	0.17
	99.0	99.7	99.10	99.13	100.00

B. Decomposed Sparry Ores.

	a.*	b.*	c.*	
Protoxide of iron	45.85	....	....	*a** has a
Carbonate of prot. of iron	——	31.19	....	brownish red color.
Protoxide of manganese	8.00	....	....	
Carbonate of Protoxide of manganese		8.48	....	*b**is a brownish black,
Magnesia	2.00	....	0.44	still crystalized.
Carbonate of magnesia		9.45	....	
Lime	0.46	....	0.60	
Carbonate of lime		1.68	....	*c** has a
Carbonic acid	36.06	....	....	black color.
Peroxide of iron	6.60	38.83	76.76	
Peroxide of manganese		....	16.56	
Silica		3.24	....	
Gangue mass	0.66	....	....	
Water		5.71	5.64	
	99.63	98.58	100.00	

C. Brown Hematite.

Peroxide of iron.........	86.35	89.27	75.70	82.27	86.12
Peroxide of manganese	0.51	0.65	......	......	0.75
Silica	0.85	......	7.61	4.50	1.70
Water, chem.–hygro......	11.38	10.08	13.32	13.26	11.43
Phosphoric acid.........	......	......	2.67	......	......
	99.09	100.00	99.30	100.03	100.00

ANALYSES OF RED HEMATITES FROM THE TERRITORY OF WETZLAR.

Peroxide of iron......	80.95	73.77	92.45	92.68
Silica	16.74	23.16	5.03	4.52
Alumina, lime and magnesia.........	0.97	1.41	0.65	2.80 (Alumina
Water..................	0.83	1.21	1.08	......
Phosphoric acid......	0.51	0.45	0.19	......
	100.00	100.00	99.40	100.00

ANALYSES OF ORES FROM THE TERRITORY OF NASSAU.

A. Red Hematite.

Iron, metallic.................	43.80	38.73	39.73	35.96
Manganese....................	trace	1.64	trace	0.73
Oxygen	18.77	16.59	17.02	15.71
Lime...........................	0.42	2.02	16.80	26.49
Magnesia......................	0.04	1.41	....	1.43
Alumina.......................	11.15	11.09	3.46	3.46
Silica	17.79	17.41	19.99	14.69
Phosphoric acid.............	1.10	1.64	0.33	0.60
Water..........................	1.17	3.70	0.95	0.61
Loss (in calcining)..........	5.85	3.63	0.50	0.25
Sulphur.......................	trace	......	0.02	trace
	100.09	97.86	98.80	99.93

B. Brown Hematite.

Iron, metallic	21.76	32.48	36.84	32.50
Manganese	7.07	trace	trace	6.97
Oxygen	11.86	13.93	15.78	16.99
Water	3.51	3.11	......	......
Alumina	15.31	13.82	6.36	1.61
Lime	5.47	......	0.65	3.09
Magnesia	2.23	0.08	trace	trace
Silica	26.11	28.42	30.26	26.41
Phosphoric acid	0.94	1.86	0.66	1.35
Loss (in calcining)	6.22	6.74	5.23	10.82
Sulphur	......	0.18	0.10	0.10
	100.78	100.62	95.88	99.74

The total production of the deposits marked

Fig 6 was in 1872: 88,000 tons { 19,550 tons brown hermatite / 68,450 tons red hermatite } in Wetzlar territory.

267,647 tons red hematite in Nassau territory.

Fig. 7 was, in 1872, 27,700 tons brown and clay-iron stone.

Fig. 8 was, in 1872, 9,650 tons brown hematite.

Fig. 9 was in 1872: 320,150 tons { 236,100 tons sparry ore. / 69,000 tons brown hermatite. / 1,550 tons red hermatite and clay ore.

Total 713,147 tons.

Before I undertake the enumerating, etc., of the exhibitors at Vienna, I shall also give a short description of the manner in which the furnaces of this group are conducted.

In a letter incorporated with the last geological report of Indiana, it is stated that the oldest furnaces of the Siegen territory are worked with charcoal for fuel, but somewhere above I mentioned that this fuel will be set aside entirely in a short time. For coke is recognized now as the true fuel even for producing the finest quality, spiegeleisen. Several establishments are already renowned for the excellent conducting of their furnaces with coke for fuel. Of these, I mention the iron works at

MUHLHOFEN,

Near Sayn, on the Sayn, a small tributary of the Rhine. The furnaces there are blown with three tuyeres of 2½–2¾ inches diameter each, 2½ lbs. pressure of the blast, and a temperature of the latter of 270–300° C.

There are in the average required per ton of iron,

4,720 lbs. of ore,
1,834 lbs. of lime,
3,152 lbs. of coke.

The yielding of the ores being about 42.25 per cent. all the year round.

The mixture for gray pig iron is:

70 per cent. of brown hematite,
20 per cent. of red hematite,
10 per cent. of clay iron-stone.

With 40 per cent of lime as admixture for flux.

For the production of spiegeleisen the mixture of ores is composed as follows:

38 per cent. of sparry ore,
20 per cent. of brown hematite,
30 per cent. of red hematite,
12 per cent. of clay iron-stone.

100

With 38 to 40 per cent. of lime for flux. The cost of production is about $25 per ton. The waste-gases of the furnaces (two) are nearly sufficient to create the necessary steam for the blowing engine and to produce the above stated heat of the blast air. Each furnace produces about 25 tons per 24 hours.

Generally, the iron masters conducting furnaces of this group use for the fabrication of

Spiegeleisen,	$\frac{2}{3}$ parts of sparry ores, $\frac{1}{3}$ parts of brown hematite, etc.
Gray pig,	$\frac{2}{3}$ parts of brown hematite, etc., $\frac{1}{3}$ parts of sparry ores.

Red hematite and iron glance, which contains up to 70 per cent. of metallic iron, are admixed in very different proportions; it is the best means for enlarging the production.

On account of the excellent qualities of the ores in past times, when charcoal was used for fuel, and the lime too far away from the establishments by missing railroads, no flux whatever was admixed; but of late, since such roads are built and the charcoal is replaced by coke, lime, of course, had to be introduced to the mixture.

The display of the iron works of this group did in no way fulfill the expectations which were entertained, on account of the mineral wealth and superiority of the ores of the different territories belonging to it. This group, with its grand richness of precious metals, presents the same in relation to Germany, what Styria and Corinthia do to Austria, Taberg and Dannemora to Sweden, the Ural to Russia, Cumberland and Lancashire to England. It is for this reason that a display was expected that would show how the marvellous ores of this group form the real foundation of the great iron and steel industry of Rhenish Prussia, as well as of Westphalia. But there are to be mentioned only:

1. I. H. DRESLER, SEN.,

Of Siegen. This firm, established in 1790, own about sixty mines, producing annually, with 760 miners, about 50,000 tons of ores of every description. The ores are partly melted in the furnaces of the "Heinrich Iron Works," near Au, on the Sieg, partly sold. The latter named establishment produced in 1872, 20,500 tons of first-class spiegeleisen in two blast furnaces, using coke for fuel, and it is far

famed for its many innovations in the manufacturing of this species of iron, and for its many skillful arrangements and its management in general. The firm owns also rolling mills at Geisweid, near Siegen, containing 11 puddling, 3 balling and 13 re-heating furnaces, for the fabrication of sheet iron and wire. The production of 1872 was 8,000 tons with 280 workmen.

2. GABRIEL BERGENTHAL & CO.,

Owners of the Germania Iron Works, near Grevenbrouh, Siegen, which has a production of 3,000 tons of ores and 2,500 tons of pig iron per annum.

3. "CHARLATTEN IRON WORKS,"

At Niederschelden, near Siegen. This work, established in 1864, has the greatest production of spiegeleisen in the territory of Siegen, using coke for fuel. The production of two blast furnaces was, in 1872, 25,520 tons, or about 70,000 lbs. per 24 hours, of which the greater part was exported to England.

4. JACOB KREUTZ, SIEGEN.

By the work of 1,200 miners, 75,000 tons of ore are mined annually, and partly smelted in furnaces at Niederschelden, owned by Mr. Kreutz, partly in the Charlatten Iron Works.

5. ROLAND IRON WORKS,

Established in 1866, produced in a blast furnace at Hardt, on the Sieg, 15,000 tons of white iron for conversion into bar iron.

6. WISSENER MINING AND SMELTING CO.,

Produced in 1872, with 600 to 700 workmen, 23,500 tons of ore, and 24,000 tons of pig iron, including 14,800 tons of first-class spiegeleisen.

7. COLOGNE–MUSEN MINING AND SMELTING CO., AT LOHE, NEAR SIEGEN.

This firm own the very oldest mines of the territory of Siegen, mining, besides iron ores, also such of lead and copper. The production of iron ores amounts to about 66,000 tons per annum; the smelting work comprises two coke and two charcoal blast furnaces, in which spiegeleisen is exclusively produced. The total production of iron amounted to 30,000 tons in 1872, of which about 1,000 tons were converted into steel, in a newly erected Bessemer work.

I may add that the charcoal furnaces are about 35 feet high, 12 feet across the boshes, that they have a hearth 32 inches wide above, 23 inches below; the tuyeres are 2 feet 10 inches above the bottom, the height of the boshes is 4½ feet, with a declination of fifty-five degrees. They produce about 10,000 pounds each per 24 hours.

8. FREDERICK WILHELM IRON WORKS,

At Troisdorf, on the Sieg, owned by the Sieg-Rhine Mining and Smelting Co., known with the iron masters by the many inventions of its general superintendent, Mr. Langen, whose apparatus for collecting the waste-gases I described above.

The establishment comprises, blast furnaces, foundry, machine shops and rolling mills. In the furnaces, ores of Siegen are melted above all others, and such of the Lahn. The production in 1872 was 19,000 tons pig metal, mostly white and spiegeleisen, 10,000 tons of bar iron and 2,050 tons of cast iron work. There are two blast furnaces, eight re-heating furnaces with a corresponding number of rolls, and seventy-three coking furnaces.

Having thus laid down, to a limited extent, the mode and results of the operative iron industry of Rhenish Prussia and Westphalia, I still have to express the regret which I feel in not having been able to make the

report as full as I wished to do. This, on account of failing to prepare such exact drawings as would have been valuable in better explaining the text. In investigating any single branch of art or industry, we should examine it in its origin, its progress, improved state and subsequent perfection, and illustrate it by figures and drawings. The true product of chemical mixtures and operations which it involves, should also, in every case, be calculated and compared with the actual results. For such a maxim, steadily kept in view, will seldom fail to disclose whatever is erroneous, and thereby lead to improvement. Conducting blast furnaces upon the most rational and economical principles is a great problem which every iron master should make as an exemplar of his own, but very often, indeed, is most carelessly neglected. And there can be even some greater questions involved in the producing of "such common material as iron," as one may say:

"The iron industry of a country, like any transformation of primary materials, by chemical or mechanical processes, into general objects of market value, is well apt for the purpose of illustrating the standard of knoweledge to which a people has risen, and the extent of business life and general wealth prevailing. Iron, the use of which is universal, is a symbol of civilization; it is no minister of luxury and refinement, but represents the honest industry of labor."

SPIEGELEISEN MANUFACTURING.

BY HUGH HARTMANN, CIVIL ENGINEER.

In two previous letters, which the late Prof. J. W. Foster, of Chicago, brought very kindly before the A. A. for the A. of S., during its sessions at Dubuque, Iowa, last summer, and which Prof. E. T. Cox, of Indianapolis, incorporated with his last Geological Report on Indiana, I spoke already of the great facilities which this State offers to the iron producers, stating that those elements, which are required for the producing of a pig iron, adapted for the Bessemer process of steel making, are marvelously combined in her natural resources as well as her other particularities.

Supported by some experience which I had in Germany, I reviewed to a limited extent the materials used there and the modus operandi upon which those iron works are conducted which produce the Spiegeleisen. (Specular, glittering iron, or Spiegeleisen—as it is called now throughout the technical world—is the raw material for the Bessemer process).

Comparing the same with the facts already obtained in Indiana, it is true to say, that she is only in her infancy as to the development of technical enterprise (mining and smelting), but there can be no doubt as to her future magnitude. That she will be a great iron producing State, and the future

seat of American Steel making, I shall try to prove this in considering

Firstly, The qualities which a pig iron must bear to be fit for the Bessemer process.

Secondly, The difierent ways upon which the blast furnaces of different countries are worked to produce an iron of the required properties.

Having thus laid out not only the preliminary, but the fundamental part of the theme in question, I shall

Thirdly, Take a survey of those questions in regard to Indiana herself.

1. OF THE QUALITIES OF SPIEGELEISEN.

The qualities of a pig iron adapted for the Bessemer process must be, briefly stated, the following:

1. Freedom from sulphur and phosphorus.

2. Presence of manganese.

Sulphur and phosphorus, noxious as they are in any kind of iron destined for the refinery process, are the greatest enemies of the Bessemer proeess.

The true spiegeleisen has a silver color and a high metalic lustre; broken into pieces, it shows large and bright, mirror like facets. All the analyses made of spiegeleisen demonstrate the presence of a certain amount of manganese, while it is also found, that the more or less glittering appearance, or the formation of large facets, depends more upon the per centage of combined carbon, than manganese. It is found, furthermore, that the state of crystallization is the same either with a large or small amount of compounded manganese. The formation of large facets is facilitated or increased, when the iron (after the tapping from the furnace) is covered with slag, because the cooling of the iron is retarded. It is therefore necessary, to accummulate in the hearth of the furnace, before the tapping, a large quantity of slag, sufficient to cover the pigs in the moulds to a thick-

ness of several inches. Should the iron be poor in carbon, the pigs will show after this operation far better facets than without it. On the other hand, when the iron is rich in carbon (when containing about ·5 per cent. carbon), this covering with slag is useless. It is also of some influence for the producing of large facets, to have the iron running very lively from the furnace into the moulds. If there is much manganese in the iron, and the iron itself very hot, a vivid oxydation on the surface of the pigs takes place.

Iron, in the constitution of which a portion of the always present silica is replaced by manganese, will rather part with the latter than the former. Iron, on the point of passing from the liquid to a solid state, will retain the manganese and expel the silica, which appears in the form of fine needles on the surface of the pigs.

Spiegleisen of different casts, appearing entirely uniform, can be of a very different chemical constitution in reference to the manganese. The buying and selling of spiegeleisen is based at present upon its standard of manganese; each cast should therefore be analysed.

The following analyses represents the chemical constitution of iron from two establishments in Rhenish Prussia, well famed for their products:

	HAMM*	HOCHDAHL*
Carbon - -	4.129	5.04
Silica - -	0.458	0.41
Copper - -	0.291	0.16
Manganese - -	8.706	7.57
Iron - - -	85.929	86.74
Sulphur - -	....	0.08
Phosphorus - -	....	....
	99.513	100.00

From Dr. H. Wedding's (Professor of the Royal Polytechnical Academy of Berlin) additional explanations to

*See Chapter II.

Perry's Handbook on Iron, I glean also the following partial analyses of German and other spiegeleisen:

	MANGANESE.	CARBON.
Analyzed by Tooky -	11.12 ℔ cent.	4.77
Analyzed by Fresenius	10.707 ℔ cent.	4.323

These and many other analyses of well known chemists seem to prove, that the chemical constitution of the spiegeleisen is not only Fe. 4 C, as taught and believed up to this time, but that the chemical formula of its composition must be:

(Fe. mn) 4 C.

II. OF THE PRODUCING OF SPIEGELEISEN IN FOREIGN COUNTRIES.

The countries which at present produce the bulk of spiegeleisen—Russia, Sweden and Germany—are, strange to say, worked upon the most different iron ores, while they, notwithstanding, come to the very same result.

A.—RUSSIA.

The country around the coast of the Baltic Sea contains very rich mineral deposits of magnetic ores and around the many lakes and scattered over the whole country, such as brown hematites.

I give here, and in the following chapters, some analyses made under the supervision of Prof. C. F. Rammelsberg, Prof. of the Berlin Royal Polyt. Academy.

BROWN IRON ORE FROM NISCHNEI–NOVGOROD.

	I.	II.
Oxide of iron - -	30.57	32.75
Oxide of manganese - -	1.55	1.00
Water - - - -	13.87	13.00
Phosphoric acid - -	2.93	3.50
Silica - - - -	......	......
Sand - - - -	50.28	47.50
Precipitated silica - -	1.08	2.50
	100.28	100.25

In No. I. the 2.93 per cent. of Phosphoric acid are equal to 1.28 phosphorus.

In No. II. the 3.50 per cent. of Phosphoric acid are equal to 1.53 phosphorus.

For fuel, charcoal is used, and at Nischnei Tagilsk they produce a spiegeleisen which is known everywhere for its excellent qualities. The iron ores (which contain, as the analysis shows, only a small amount of manganese) are mixed with an iron—containing Brownit—bearing 40 per cent. of manganese and 10 per cent. of iron. The yielding mottled iron contains in the average 1.2 per cent. of manganese.

At Watkinskii they melt this iron in a cupola furnace and adding some 12.15 per cent. of oxide of manganese (Manganit or Pyrolusit) a spiegeleisen results, which contains from 5 per cent. to 6 per cent. of manganese, and which is especially suitable for the manufacture of steel.

B.—SWEDEN.

The Scandinavian peninsula is very rich in excellent iron ores, occurring in three different classes.

The first class, containing from 6 to 10 per cent. of manganese and represented by the manganiferous magnetic iron ores of all the primitive rock formations, as Granite, Gneiss, etc., is very pure. Quartz very seldom occurs, while there is oftentimes some calcareous gangue mass present, enough not to require an admixture of flux to the ores in the blast furnace. Phosphorus is very seldom, while sulphur, even in the very best ores (of Dannemora) appears.

The second class comprises series of red hematites, both in a compact or a soft form, in veins forming gangues in quartzite. This class, therefore, is accompanied by some silica.

The third class is represented by those brown ores of the very latest formation, occurring at the bottom of lakes or marshes.

The district of Wermeland, the principal geological formation of which is the Gneiss, bears magnetites in the

neighborhood of Presberg, Taberg, etc., and red hematite in the vicinity of Philipstadt and Carlstadt.

Delarne and Westmorland are well known for their manganiferous magnetic ores of the crystalized slates in the Gneiss. The mining regions of Bispberg, near Sater and Schisshyttan, Ramshyttan in Dalesarlien are the note-worthiest. In the following are shown some analyses of ores:

MAGNETIC ORES.

Peroxyde of iron	69.74	75.87	70.23	70.41	71.85	70.71
Sesquioxyd of iron	30.00	24.13	29.65	29.40	28.00	28.78
	99.74	100.00	99.88	99.80	99.85	99.49

BROWN IRON ORE.

Oxyd of iron	62.56
Oxyd of manganese	2.60
Magnesia	5.80
Silica	20.40
Phosphoric acid	0.68
Water, etc	7.50
	99.54

GRANULAR IRON ORE.

Iron	43.53
Manganese	3.45
Lime	1.80
Magnesia	0.08
Alumina	3.41
Silica	39.84
Phosphoric acid	0.18
Sulphuric acid	trace
Water	7.70
	99.99

For fuel, either charcoal alone, or a mixture of hard charcoal and coke, (equal parts,) is used. Generally, the blast furnaces are blown with hot blast and about 30 per cent. of lime are added to the mixture of ores for flux.

The general features of the greater part of the Swedish furnaces are the following: The cavity has the form of an elongated ellipse, whose small diameter is about 7½ feet across, at a height of 14 feet above the bottom of the hearth; hence, at this part, the interior space constitutes a belly corresponding with the upper part of the boshes. In other respects, the details of the construction resemble those of England, Belgium, Rhenish Prussia, and others. Such furnaces are related to yield (by only 30 feet height) 47 per cent of iron.

Fig. 1.

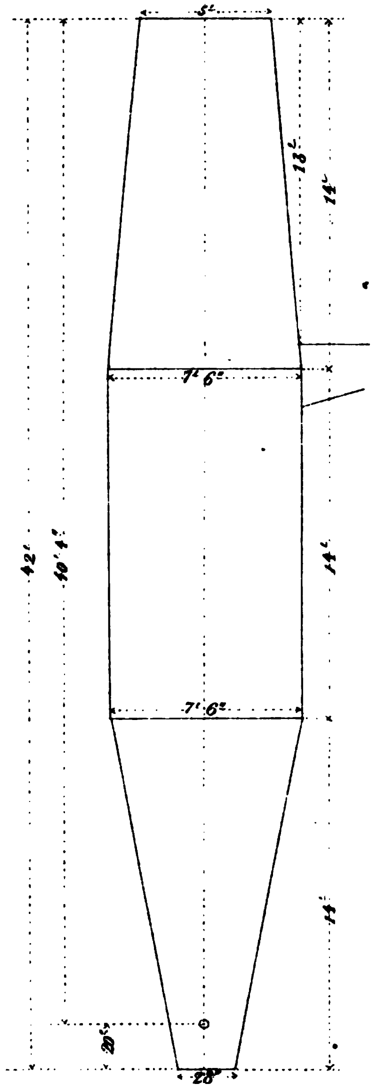
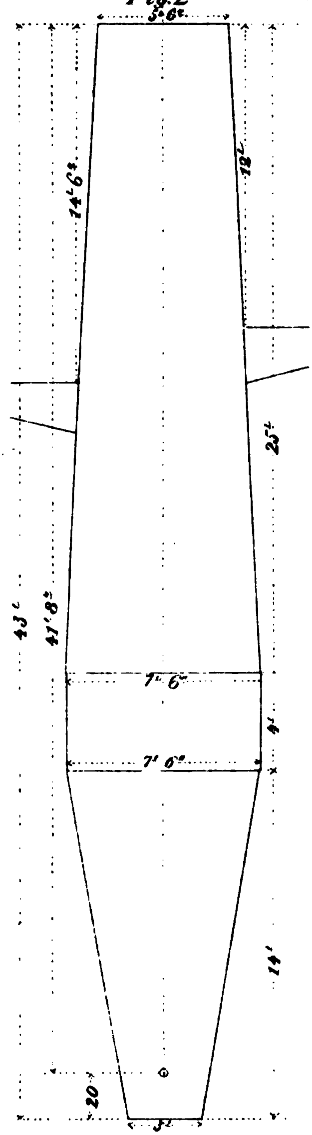


Fig. 2



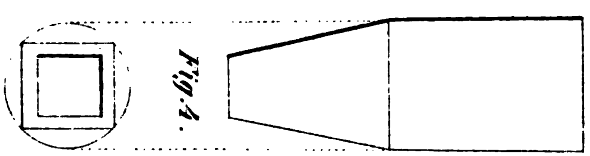


Fig. 4.

Fig. 3.

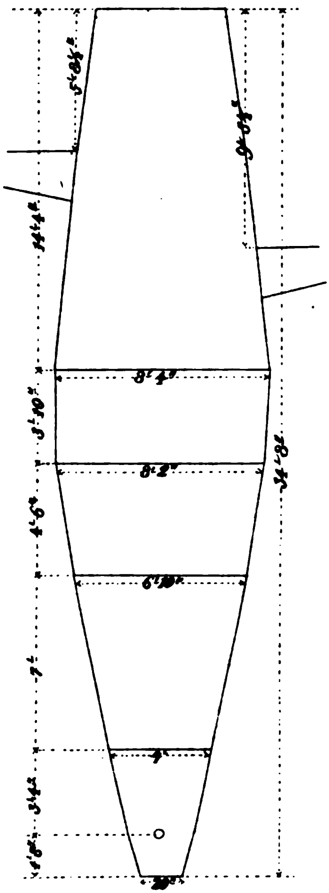


Fig 7.

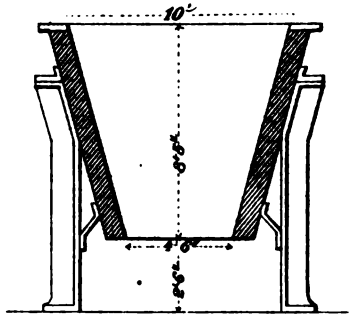


Fig. 6.

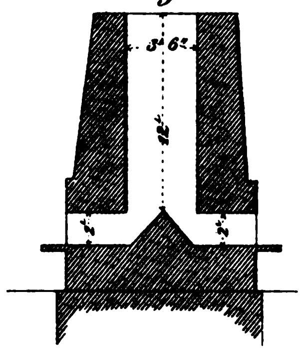


Fig 5 a.

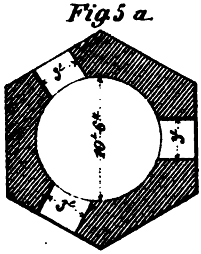
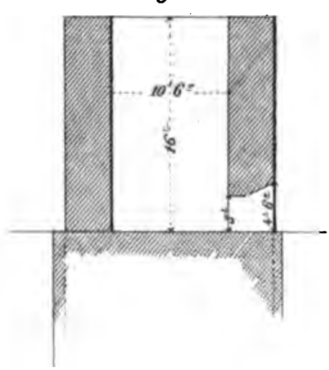


Fig. 5. b.



At Hammarby the blast furnace has the dimensions shown in Fig. I, Tab. I. She is blown with three tuyeres 22.7‴ (1.89 inches) diameter; the noses of the two tuyeres, on opposite sides having each a diameter of 19.9‴ and the nose of the tuyere in the posterior wall of 18.5‴. The gases are used for the heating of the blast air and for the calcining of the ores. They (the gases) are taken from the furnace at a point about 13′ below the tap.

The usual charges are composed each of,

Fuel—32.7 cubic feet charcoal=316.4 lbs.*

Ores—iron glance (containing quartz), with 44 per cent. iron=340.0 lbs.; red hematite, with 50 per cent. iron =238.0 lbs.; magnetic iron ore, with 56 per cent. iron =42.0 lbs.

Flux—lime (dolomitic), nearly 24.9 per cent. of the ores =153.0 lbs.

The number of charges given in 24 hours is about 48 or 50. The yielding of the mixture (ores and flux) is from 38 to 40 per cent. of pig iron, partly gray, partly mottled. The blast is heated to 200° C, (392° F,) and has a pressure of 20.4–23.1‴.

The blast furnace at Forssjoe is of the dimensions as shown in Fig. 2, Tab. I. The furnace is blown with two tuyeres of 28.3‴ diameter, the noses having a area each of 3.6 square inches. The gases for heating the blast air are taken about 12′ below the tap, those for the calcination of the ores, 14½′ below.

Each charge is composed of,

Fuel—charcoal, 43.2 cubic feet=401 lbs.

Ores—manganiferous magnetits (containing quartz), =723 lbs.

Flux—lime (16.43 per cent of the ore)=119 lbs.

*1 Swedish ton=6.3 cubic feet Swedish.

2.2046 lbs. English (avoirdupois)=2.3511 Swedish.

The blast air is heated to 170° C. (312° F.) and has a pressure of 16.3 to 17.7‴. The yielding from the mixture is 44.4 per cent. of mottled pig iron.

The blast furnaces at Hasselfors are represented in Fig. III, Tab. I. The upper part of the shaft is conical. Below the largest diameter, the hearth commences by means of an arched part, which is circular as far as to the vicinity of the tuyeres, and elliptical from there to the bottom. The greatest diameter of the ellipse (2′10″ reaches from the posterior wall to the tymp, while the smaller one (2′5½″) extends from side to side. The tuyere of the posterior wall has a diameter=21.9, those of the sides respectively 25.6 and 27.2 inches. The diameters of the noses are respectively, 1.91–2.31–2.31 inches.

The gases for the roasting of the ores are taken 9′5½″, those for the hot air stoves 5′8½″ below the tap.

Each charge is composed of,

Fuel—charcoal, 43.2 cubic feet=394.4 lbs.

Ores—iron glance (with 45.8 per cent. metallic iron,) =272.0 lbs; magnetic ores (49.7 per cent. metallic iron) =663.0 lbs; rich manganiferous calcareous gangue containing brown hematite=153.0 lbs.

Flux—lime=17.0 lbs.

The number of charges given in twenty-four hours is about thirty; the yielding is about 45.5 per cent. of a white, silvery iron, the pigs showing gray spots toward the centre. The temperature of the blast air is 200° C. (392° F.), the pressure is about 14.3‴.

It is found that the iron yielded from the manganiferous ores is not only of an excellent behavior in the Bessemer furnace, but also very much qualified for the producing of a first-class steel. The ores containing some quartz are found to be also very suitable for the Bessemer process as long as they are mixed with other good natured ores.

It is furthermore a fundamental rule that all the different ores are carefully calcined. An accuracy in this regard may

enable the iron master to make proper use even of an ore of medium or bad quality. For, nevertheless it is a fact now that a small percentage of sulphur (about 0.15 per cent.) can be abstracted or rejected from the iron, in Bessemer's process of refinery, this depends upon the fact that the crude metal must be in every other respect of the most suitable properties. It is a singular but stated fact that in using an iron, resulting from a period of derangements in the blast furnace, the amount of sulphur very often seems to be increased in the refinery process of Bessemer. The coincidence with other different methods of refining, is very eminent. The German forge, which is generally worked upon a gray pig, is very well adapted for the utilizing of a sulphurous iron. The other methods, the Wallon, Lancashire, and French or Catalan method, refining white iron, require an iron nearly entirely free of sulphur, for the producing of a good, malleable iron. It is therefore absolutely necessary to diminish the sulphur in the crude metal as far as possible, to be suitable for the Bessemer process. And for this reason the ores have to be carefully roasted.* The furnace has always to be kept in a good working condition, the slag must bear a superamount of lime, and the heat of the blast has to be kept at a very high degree. The materials must have a regular, not too rapid, slope in the boshes, and the deoxydizing as well as the reducing process of the ores has to take place in the proper zones of the furnace. The color of the slag is the surest test of the behavior of the furnace, as it indicates the quality of the product; a yellowish, green tinted slag, slightly covered with a brown translucent coat, smelling from sulphuret of calcium, when sprinkled with water, (the excess of lime having absorbed and carried off the sulphur), will always be found to be the unmistakable sign of a good working condition of the furnace.

*In the following chapter I shall say more about the roasting of the ores.

As to the impurity of posphorous and other obnoxious substances, there seem to exist no certain reports of the Swedish iron works, probably, because there are so many good natured ores, free from such impediments, that the former can be very easily avoided.

For the better understanding, I add two analyses of slags from the furnaces at Edskin:

	I. Containing oxygen.			II. Containing oxygen.		
Silica	47.30	24 50	......	46.37	24.08	?
Alumina	1.66		0.78	4.30		2.01
Lime	24.34		6.95	38.64		11.04
Magnesia	22.86		9.19	7.40		2.96
Potash	0.62		0.10	0 30		0.05
Soda	0.09		0.02	0.14		0.04
Protoxyd of iron	0.99		0.22	0.95		0.21
Protoxyd of manganese	1.40		0.32	1.86		0.42
Copper	1.40		....	trace		....
Phosphorus	trace		....	......		....
Sulphur	0.07		....	0.03		....
	99.73	24.50	17.53	99.99	24.08	16.73

It remains to say that the above mentioned iron works export their common product to the Bessemer establishments in England and Northern Germany. The iron works of Dalekarlien, which produce a spiegeleisen from a mixture of Knebelit and manganiferous iron garnet, containing in the average about 42 per cent. of metallic iron and 13 per cent. of manganese, export also their iron to Germany. It is rumored that the slag of the furnaces of this district contains sometimes 4 per cent. of sulphur and as much as 16 per cent. of manganese, the spiegeleisen itself bearing variably from 9 to 13 per cent. manganese and about 4 to 5 per cent. of carbon, silica, etc. Invariably it is also experienced there, that, as soon as the manganese exceeds a certain standard, the carbon diminishes proportionaly. Should the iron contain as much as 30 per cent. of manganese, the

carbon is found to be reduced to 0.40 and even to 0.25 per cent.

The cost of the production of a ton of iron is very different, according to the different localities. In the average a calculation can be made in the following manner—percentage for amortization and the interests of stock excepted—for the production of 1 cwt. are afforded:

2.1 cwt. ores at 13.2cts. per cwt.	26.4c.
15 cubic feet charcoal at 2.4c. per cubic foot.	36.0c.
Wages	6.0c.
Repair	2.4c.
Wear and tear	6.0c.
	77.8c.

Or, per one ton English (of 2,000 lbs): $18,36, while the market price (at the establishment) is about $24.8–25.0, giving therefore to the interested persons a net profit of from six to seven dollars per one ton.

C.—GERMANY.

The production of spiegeleisen in this country is larger than in any other, but the same is confined to only two, comparatively small districts: the northern part of Rhenish Prussia and the south-western part of Westphalia, also a province of the Kingdom of Prussia.

THE ORES

used for the manufacture of spiegeleisen are found in gangues which are interjected in the Devonian formation of the eastern borders of the Rhine and the Hartz Mountains. They are to be classified

1. As sparry iron ores, or carbonate of iron and manganese ($Fe. O. CO_2 + Mn O. CO_2$). These ores are often impregnated with quartz, copper pyrites, sulphates of iron, lead and zinc. It is therefore absolutely necessary, that a

very careful roasting of the ores takes place in order to reduce the sulphates, which the ore, as presented by nature, may contain.

2. As red or brown hematite.

Both varieties of ore contain, the former more, the latter less, manganese. Besides these two principal classes some argillaceous carbonate of iron, or clay iron stone is used as an auxiliary in some establishments.

The following tables give an average of the chemical constitution of several of the best known mines:

SPARRY IRON ORE.

	1	2	3	4	5	6
Protoxyd of iron........................44.9	44.9	47.96		50.72	47.20	....
Carbonate of iron...........................	....	....	74.47	....	....	82.63
Protoxyde of manganese...........10.3	10.3	9.50	....	7.64	8.34	....
Carbonate of manganese..................	....	....	17.08	....	....	15.45
Magnesia...	1.0	3.12	....	1.48	3.75	....
Carbonate of magnesia.....................	....	....	5.75	....	....	....
Lime..	1.0	....	....	0.40	0.63	....
Carbonate of lime.............................	....	....	1.34	....	....	....
Carbonic acid..................................	37.0	39.19	1.08	38.90	38.85	....
Silica or gangue mass......................	4 2	....	....	0.48	0.95	....
Water..	....	....	....	....	....	1.91
	98.4	99.77	99.72	99.62	99.72	99.99

No's 1, 2, 3, are from mines at Stahlberg, near Musen, in Westphalia.

No. 4 are from mines at Kesselgrube, near Siegen.

No. 5 are from mines at Kirschenbaum near Siegen.

No. 6 are from mines at Brische, near Siegen.

RED HEMATITE.

Iron	38.72	38.73
Manganese	0.81	1.64
Oxygen	16.90	16.59
Silica	29.15	21.41
Alumina	8.40	11.09
Lime	0.16	2.02
Magnesia	0.14	1.41
Water	4.89	7.33
Phosphoric acid	0.01	0.64
Sulphuric acid	0.13	....
	99.31	100.86

These analyses are taken as a fair average from several others of a group of mines near Wetzlar on the Lahn, a tributary of the Rhine. They give the best picture of all the ores of the surrounding mining districts. These ores are extensively consumed by all the works on the Lower Rhine.

BROWN HEMATITE.

Iron	39.33	25.00
Manganese	2.00	4.59
Oxygen	17.80	12.65
Lime	0.52	0.46
Magnesia	trace	....
Alumina	12.50	7.23
Silica	16.18	33.01
Water, chemic. combined	2.40	2.40
Water, hygroscopic	8.99	14.44
Phosphoric acid	0.09	0.17
Sulphuric acid	0.27	0.03
	100.18	99.98

The ores are in the vicinity of Linz on the Rhine; they are also extensively used.

According to some news which I received lately from Dusseldorf, there is, since a short time, also used in combination with the ores mentioned, to a limited extent, an ore imported from Spain, sparry ore as well as brown iron ore, the analyses of which are in an average the following:

	BROWN IRON ORE.	SPARRY ORE.
Protoxyd of iron	....	53.17
Sesquioxyd of iron	70.10	....
Sesquioxyd of manganese	3.65	3.70
Lime	0.32	2.30
Magnesia	0.23	3.80
Alumina	6,33	....
Silica	13.66	7.60
Water and carbonic acid	5.71	29.71
	100.00	100.28

THE ROASTING OR CALCINING OF THE ORES,

is executed mostly in kilns of which there are about five different kinds. One group or class has a grate, upon which a fire is sustained for warming the kiln, and which is afterwards taken away, while the four other classes have no such grate, and differ in the following way:

The first class has a cylindrical shaft with a smaller, rectangular hearth below (Fig. 4 Tab. I), a horizontal bottom and two openings for the extracting of the roasted ore.

The second class (Fig. 5) has a shaft bearing the same dimensions from the top to the bottom, and three apertures on the horizontal bottom

The third class (Fig. 6) has a cylindrical shaft and a conical bottom, the top of the cone laying in the centre-line of the kiln, with two apertures.

The fourth class (Fig. 7) represents a truncated cone, supported by pillars, the greatest diameter of the cone forming the top.

The manner of conducting the process of roasting is the same in all cases. For fuel small coke is always used, of about one-half to three-fourth inches diameter. The proper charge of ore is spread evenly over the coke to a depth of six to eight inches and the fire is pushed moderately, while the roasted ore is progressively withdrawn below.

As to the chemical action taking effect in roasting, I may remark the following:

Sparry ore is natural carbonate of iron and is, in its purest state, a compound of $Fe\ O,\ CO_2$. But in the sparry ore mostly always a part of the iron is replaced by manganese, and this in certain proportions. Likewise are lime and magnesia proportional substitutes. According to Rammelsberg the ore of Musen, (near Siegen), is $Mn\ O,\ CO_2,+4\ FeO,\ CO_2$, or is composed of

Peroxyd of iron - -	49.01=37.85 metallic iron.
Peroxyd of manganese	12.45
Carbonic acid - - -	38.46
	99.92

Sparry ore, as a crude mine, is very indifferent to reduction, but roasted and submitted for a certain period to a process of decantation and decomposition—by means of the influence of the atmosphere and humidity—it can be very easily reduced, giving in the furnace the very best material for the Spiegeleisen. The sparry ore oftentimes turns over by natural decomposition into brown hematite, which, nevertheless always contains some carbonate of iron, and much hygroscopic water.

By means of the chemical process: the roasting, decomposing and decanting:

1st. The peroxyd changes into sesquioxyd.

$Mn\ O,\ CO_2+4\ Fe\ O,\ C\ O_2$—$Fe_2\ O_3$, 56.21=81.89, containing 59.78 iron. $Mn\ O$, 12.49=18.11, because the $Fe\ O,\ CO_2$ changes to $Fe_2\ O_3$=68.34 and in 100 parts of $Fe_2\ O_3$ are 69.34 Fe.

2d. The phosphoric acid, always combined with lime or iron, is insoluble in water, but even slightly acidulated waters dissolve it.

It is for this reason that the sulphuric acid, formed by the decomposition of the sulphates acts as a solvent upon the phosphates.

If the phosphorus of the ores is combined with the oxydized iron itself, it will be ejected to a small amount from the molten iron instead of a corresponding part of silica, which will join the iron.

If the phosphorus is not combined with the iron, but with other compounds, such as lime, magnesia, or alumina, it will go for the greatest part into the slag, as soon as the same bears an superamount of bases. But, if the slag is acid, the silica absorbs all the bases and the phosphorus will always join the iron.

3d. The bisulphuret of iron changes into sulphate of iron ($Fe\,S_2$ into $Fe\,O, SO_3$ in taking up two parts of O,) which is very soluble in water. It is to be remembered, that the sulphur never can be ejected from the ores by means of the roasting process alone; decaying and decanting have to do the rest. It is therefore entirely incorrect to bring such ores into the blast-furnace as soon as they come from the roast-kiln; three or four months at least, they should be subjected to the two latter processes named. For, if there is not a large superamount of lime in the charge of the furnace, or in the slag, the sulphur will always join the iron. In offering sulphur to a large amount of lime it forms sulphuret ot calicum, Ca S, which is chemically combined as follows:

1 part S, 44
1 part Ca, 56

100

In forming the calculation for the construction of the slag

it must, therefore, always be remembered that 100 parts of sulphur afford:

127.13 calcium.
178.15 lime.
316.60 carbonate of lime.

The formation of large quantities of this Ca S often takes place in furnaces using coke for fuel. It appears as a fine white powder, covering the tunnel-head and the tymp of the furnace. Naturally can its amount in a slag be of the most different quantities, but slag, containing much of it, is heavy and crumbles under the influence of the atmosphere to a coarse powder.

In conducting the calcination, care has to be taken not to expose the ores to a too great heat. For over-roasted ores, which have a vitrified appearance, resist very much the reduction, because the lime or other bases can not operate on the same. Such over roasted ores should always be charged to the furnace only in small quantities, mixed with others.

Having explained somewhat the chemical action of the roasting process, it remains to say something about its economy.

At Charlottenhutte, near Siegen, where a kiln of the second class is in operation, the diameter of which is 7′, and another one of 11 feet diameter, each about 15′ high, they roast—

In the smaller kiln: 6 wagons of 40 cwt.=24,000 lbs. per 24 hours, with an expenditure of 10 cubic feet fuel. The wages paid are 18c per wagon.

In the larger one: 10 wagons of 40 cwt.=40,000 lbs., with 17.8 cubic feet fuel in the same time; same wages

At Rolandshutte, a kiln of class 4 is in operation, 9′ high, roasting daily 40,000 lbs. of ore by means of 10.14 cubic feet of fuel, and 12-13.2 cts. wages per 4,000 lbs. roasted ore. Time the same as above.

At Storch & Schoneberg, near Gosbach, a kiln of class 1., 14½′ high, 6′ wide, is in operation roasting 28-32,000 lbs.

ore in 24 hours, with an expenditure of 16-17.8 cubic feet fuel, and 12-14.4 cts. per 4,000 lbs., for wages.

At Hainer Hutte they use a kiln only 5′ wide but 15′ high, of class 2, roasting 20,000 lbs. in 24 hours, using 13 cubic feet of fuel.

These examples show, that the production increases with the width of the kiln, and that the consumption of fuel increases with the decreasing production.

I can not omit mentioning another kiln of late construction, which is found to be working always in a very economical manner. It is constructed with two grates, one above the other. Its height varies from 18 to 20 feet, the diameter from 9½ to 10 feet. The usual charges are 8.4 cubic feet fuel and 4,500 lbs. ore, alternately spread above the upper grate. A fire is maintained in the lower grate and the withdrawing of the roasted ore takes place once in 24 hours by means of pulling out the upper grate-bars. The production of this kiln amounts to 45,000-50,000 lbs. per 24 hours.

It remains to remember that besides the expelling of the carbonic acid, water, etc, the roasting affords the very best means for the separation of the quartz. The roasted pieces are broken down to the size of nuts, and while the ore itself bears a dark, reddish brown color, the quartz is of a pure white appearance, so as to be easily recognized.

It is stated by experience that:

The magnetic ores lose..................	3–5 per cent.
Iron-glance and hematite, red.........	3–5 per cent.
Hematite, brown..................	10.5–14.7 per cent.
Sparry ore..............................	28–35 per cent.
Argillaceous ore.........	18–30 per cent.

of their weight in roasting, but also that all compact ores, after some time, take up 2 per cent. hygroscopic water, and all soft ores 6 per cent. hygroscopic water.

Furthermore: that fuel, (coke cinders) of a size not less than ⅓ and not more than ⅔ diameter, answers the best, and that

One part of coke cinders (by weight) is sufficient for 20–30 parts of ore.

One part of charcoal (by weight) is sufficient for 10 parts of ore.

One part of crude coal (by weight) is sufficient for 5–8 parts of ore.

I shall pass now to describe a few of the iron-establishments best known for the Spiegeleisen which they produce. To enumerate all would exceed the limits of this paper, for there are over fifty, all of good fame. I shall divide them in two groups.

FURNACES USING CHARCOAL OR CHARCOAL AND COKE, MIXED, FOR FUEL.

As an example of this group I name the Laher Iron Works, near Siegen, in Westphalia. The blast-furnaces of this establishment belong to the Cohn-Musner Iron Co., and use either pure charcoal or pure coke, seldom a mixture of both, for fuel. If charcoal is used, the charges are composed of

30 cubic feet charcoal of hard wood,
1,035 lbs. roadside ores,
180 lbs. lime (17.5 per cent. of the ore.)

If coke alone is used, they are composed of

42 cubic feet coke.
21.97 lbs. roadside ore,
602 lbs. lime (27.4 per cent. of the ore.)

If a mixture of coke and charcoal is used the charges consist of

10½ cubic feet coke,
20 cubic feet of charcoal,
1,233 lbs. roasted ore,
360 lbs. lime, (29.2 per cent.)

The number of charges given in 24 hours is, in the average, forty.

The principal dimensions of the blast furnaces are the following:

DESCRIPTION.	Dimensions Feet.
Height, total	4.24
Height of the hearth	4.3
Height of the boshes	9.6
Height of the cone	28.5
Height of the chimney	6.0
Width of the bottom of the hearth	4.3
Width of the upper end of the hearth	4.3
Width across the boshes	11.3
Width of the mouth	5.3
Height of the center of the tuyeres above the bottom.	2.1

The temperature of the blast air is, in the average, 570° F., but this is regarded as not sufficient. The latest news received from that place states that the company is engaged in the building of two more hot air ovens after the best and latest plans, thus giving four heating furnaces to each stack.

Each furnace is blown with three tuyeres. The diameter of the nose pipes varies according to the nature of the fuel used, also the pressure; the former changing from 16.6 to 21‴, the latter from 16 to 22.‴

The waste gases of the furnaces are used for heating the steam boilers and the hot air ovens. They are taken near the top of the furnace, which is closed with a cover and opened for each charging.

To produce a good spiegeleisen great care is taken to conduct the furnace in such a manner that the charges slope down very regular and slowly, in order to expose the manganiferous ores as long as possible to a rigorous deoxydizing and reducing process. For only in such a manner can it be successfully entertained that the highest possible

amount of manganese be reduced and combined with the iron.

For the same reason the temperature and the pressure of the blast have to be kept at a high degree. The smelting zone particularly—that is the point at which the carbonized iron is brought to a liquid state, has to be kept as near as possible to the tuyeres (or, in other words, as low as possible in the hearth), for when the room of this zone expands too much, the heat never can be great or concentrated enough to produce the process wanted—the joining of manganese and iron. Should it nevertheless happen that this zone goes too high (as it is often the case in those furnaces of Westphalia, which are worked upon a very porous coke), proper remedies have to be applied, such as diminishing the pressure, charging of soft ore, moistening of the same, etc.

As to the cost of producing spiegeleisen at Laher, the following data are given:

During a period of six days (by coke and charcoal mixed) were

CONSUMED.	AT A COST OF.	PRODUCED.
190 tons of roasted ores	$745 00	28,333 lbs. per day, or 85 tons in 6 days.
55½ tons limestone	41 75	
6,150 cubic feet charcoal	339 25	
48½ tons coke	174 75	
For breaking of 55½ tons limestone	7 00	
For transportation of slag	13 75	
For wages	55 00	
For general cost, wear and tear	28 00	
	$1,404 50	

Each ton costs, therefore, $\frac{1404 \cdot 50}{85}$ = $16.53. From this statement it follows also that

1. The yielding of the pure mine was....44.73 per cent. of metallic iron
2. The yielding of the mixture (ore and lime)....34.60 per cent. of metallic iron
3. Per ton of iron were consumed—coke....1,140 lbs.
4. Per ton of iron were consumed—charcoal.... 651 lbs.
5. Per ton of iron were consumed—ore....4,235 lbs.
6. To 100 lbs. ore were consumed—lime.... 29.2 lbs.

In using pure charcoal, the price of one ton increases to about $18.50; in using pure coke, the price of one ton diminishes to about $15.

FURNACES USING COKE FOR FUEL.

All the establishments of a later existence now use simply coke for fuel. The iron works at Sayn, Charlottenhutte, Hamm, Oberhausen, Duisberg, Hochdahl, etc., are based entirely upon the employment of this material. By all evidence it is a fact now—certainly after much trouble and many fruitless trials, as I stated at another place—that coke is preferable to charcoal or a mixture of charcoal and coke, because the heat can be far more increased in the former than in the latter case, and we know that "great heat" is one of the requirements for the production of a good spiegeleisen. Of course, the coke has to be of a first-class quality, free from a noticeable amount of ashes and sulphur. Past experience has proved that, in using coke, more manganese joins the iron, as if the same ore was worked by means of charcoal. Ores very rich in manganese are better treated in the furnace with coke than with soft charcoal.

The rules for conducting coke blast furnaces are, in general, the same as for charcoal—I refer, therefore, to those mentioned above.

Mostly all the furnaces of this group are blown with three tuyeres, some with five and seven (one in the posterior wall and a set of two or three at opposite sides), the nose pipes having from two to three inches diameter, with a pressure of the blast air of from two to two and a half and three pounds per square inch, and a temperature of 350 to 400° C. (6750° F.). The furnaces have a capacity so as to produce 60,000 to 80,000 pounds per 24 hours; the dimensions are mostly the following:

DESCRIPTION.	DIMENSIONS. Feet.
Height, total	56 to 58
Heighth of the hearth	6 to 7½
Height of the boshes	10 to 12
Height of the cone	38 to 40
Height of the chimney	8 to 9
Width of the hearth, upper part	3½ to 4½
Width of hearth, lower part	3 to 3½
Width across the boshes	13 to 15½
Width of the mouth	9 to 9½
Height of the center of the tuyeres above the bottom	2½ to 3
Square contents of the mouth—sq. ft	63.6 to 70.8
Square contents of the boshes—sq. ft	133 to 189

The charges of the furnaces at Hoehdahl, Duisburg, Hamm and Oberhausen, are, in the average, composed as follows :

Coke—1,680 lbs.; ore—2,800–3,500 lbs.; lime—1,200–1,400 lbs. (35 to 40 per cent.).

Others charge their furnaces in the following manner :

Coke—2,400 lbs.; ore—3,000–4,500 lbs.; lime—1,570 lbs. (35–40 per cent.).

In the average all the furnaces use per 1,000 lbs iron :

Coke—1,250–1,900 lbs.,
Ore—2,500–2,600 lbs.,
Lime—850–900 lbs.

The above mentioned analysis of iron from Hochdahl and Hamm give a good idea of the excellent quality of the iron produced in all these furnaces.

Consequently, one finds now-a-days Bessemer furnaces everywhere and the fabrication of cannons, rails, tires, implements of every description has already reached a point where a "halt" is impossible.

It is from this state of affairs, not only in Germany, but also in Sweden, and Russia, that I derive my judgment.

D.—INDIANA.

The Bessemer-steel manufacturers of our country thus far could not very well do without the peculiar kind of English iron, which resembles very much the Spiegeleisen. But I do not say too much in stating, that the time is not very distant when, throwing overboard such an auxiliary, Indiana will be the State, where not only the crude metal for the Bessemer steel will be produced, but where also the steel manufacturing process itself will open a new era to her health and wealth.

The block coal of Indiana is unsurpassed by any other fuel. Profs. Cox and Foster are the developers of the extensive beds of this marvelous coal, and their geological reports are so well known that I can not do better than refer to the same. Blast furnaces, rolling mills and also steel works have tested the new fuel thoroughly and severely, with results leading to the conclusion, that there is no better fuel whatever. The blast furnaces at Brazil, Knightsville, Shoals, Harmony and Terre Haute, produce by means of this block coal an iron of superior quality, proving therefore, the adaptability of the block coal for smelting purposes.

There are also iron ores in different counties of the south-western part of the State, well adapted for admixture. It remains only to bring good natured ores to the coal. Every where in the manufacturing centres of England, Belgium, France or Germany, it is always found to be more economical to conduct the iron ores to the coal, than the latter to the former. Experience of decades has proved this to be a fundamental law for every establishment, which pretends to be a well conducted one.

And the facilities in this regard are excellent for Indiana. To the north as well as to the southwest she is connected by means of rail with countries bearing a superamount of splendid ores, well adapted for the fabrication of Bessemer crude pig iron. These countries are: the Lake Superior iron region in the north—the Iron Mountain region of Missouri.

To commence with the northern region, I give below a series of analyses, which will give the best testimony of my assertion of their being suitable for Bessemer crude metal, for in comparing these analyses with those mentioned above under Sweden and Germany, one must come to the conclusion that the ores bear exactly the properties which are wanted for the production of Spiegeleisen.

There are five varieties of ores in the Lake Superior region:

1. The most valuable is the specular hematite, a very pure anhydrous sesquioxyd, occurring either granular or massive. It yields from 60–70 per cent. of metallic iron.

2. A soft hematite, very much resembling the brown hematite (limonite) of Pennsylvania and Connecticut, and generally associated with specular ore, from which it is supposed to be formed by decomposition and disintegration. It is very easily reduced in the furnace, yields about 50–55 per cent. of metallic iron and is of a very porous structure.

3. Magnetic ore, from which very likely the specular ore originated, by some metamorphic action. In some of the mines it is of a dark, bluish, black color, highly penetrated with crystals. It is very heavy, and, when free of quartz, resembling almost black oxyd of iron. It yields from 70–72 per cent.

4. Flag or slate ore, a silicious hematite, containing less metallic iron and of a very indifferent character in the furnace.

5. Silicious iron ore containing a variable amount of manganese and deposited always in the vicinity of the flag ore. This ore is of the greatest value as an admixture, for the smaller percentage of metallic iron is favorably replaced by the valuable manganese.

All manufacturers of iron understand the great advantage of having such a variety of ores. In England, the foremost importer of iron into the United States, can not do well without drawing upon Sweden and Russia for the best qualities of ores. The magnetic ores of Lake Superior have been sufficiently tested to prove that they produce the best quality of iron, and it is known that from a mixture of the magnetic with the different hematites of this district alone, can be produced every grade of iron that can possibly be required. The ores, without any notable percentage of sulphur, phosphorus or other obnoxious foreign substances, are embodied in mines, the gangue-matter of which are silicates of iron, alumina, lime and quartz.

Analyses of ores from the Marquette district are contained in the following table:

Iron, metallic, -	64.0	58.0	67.0	66.0	58.0
Oxygen, - -	27.0	24.0	26.0	28.0	24.5
Alumina, - -	2.0	2.0	1.5	2.5	3.5
Lime, - -	0.2	0.8	1.0	1.7	2.5
Gangue matter, -	6.5	15.0	4.5	1.5	11.0
	99.7	99.8	100.0	99.7	99.5

Such ores need no careful calcination, because nature itself has performed the process of decomposition.

Some later discoveries prove that there is also in Spurr Mountain district a deposit of manganiferous ores. Specimens collected for analysis from many parts of the outcrops of this new bed and from loose masses, have the following constituents:

Metallic iron	67.32
Oxygen	25.70
Oxyd of Manganese	1.01
Silica	3.06
Lime	0.12
Water	0.57
Alumina	2.12
	99.90

And it is already found that the percentage of manganese increases with the depth, and there are reasons to believe that this manganiferous ore will be found abundantly throughout the whole district. The ores of the Iron Mountain mine contain also this highly prized metal. Some of this ore has already been shipped and most successfully tested and used in the manufacture of Bessemer crude metal.

Other ores have been tested and found to possess a peculiar quality as compared with others, being equally prolific in the yield of metallic iron. It is the presence of large quantities of carbonate of lime in the body of the ore that gives it its particular character. It is this that at once recommends it to iron producers, for this ore is eminently fitted for mixing with other and especially silicious ores. The ore is said to contain from 45 to 50 per cent. of iron and 15 to 20 per cent. of lime. That this is an eminently important service to the metallurgy, and that such an ore must take a place in the very first rank even among the other rich Lake Superior minerals, will be admitted by every one who looks at the question in a practical light. It will produce economy in smelting, in supplying a lime flux in its most favorable conditions, and in allowing the use of a cheaper kind of ore (Indiana ore) in mixture with it, without introducing any deleterious substances to injure the quality of the iron produced. The blast furnaces of the Lake Superior iron district, numbering to about fifteen, produce an iron excellent in quality. They are, up to this time, using charcoal for fuel, except the Marquette furnace, which runs on bituminous coal from Pennsylvania.

The expenses per one (1) ton of iron are about:

$13 50	for fuel.
6 75	for ore and flux.
6 75	for labor, etc.
$27 00	

It is but fifteen years ago since the first shipments of the ore took place. Since that time mines have developed into an inexhaustible source of wealth, proving the superiority and excellency of the ores. From 1,500 tons of ore in 1855 the shipment increased to over one million of tons in 1872. The largest portion of the ores go to Cleveland, whence they are reshipped to the coal fields of the Mahoning and Shenango valleys by rail. The average cost of mining and delivering ore on the cars, at the mines, is estimated at $2.00 per ton. The cost of transportation to Cleveland via Marquette was last year $4.25. At these rates the ore is put upon the docks at Cleveland at a cost of $6.25, where it is sold at $8.00 and upwards.

About one hundred furnaces in Ohio and Pennsylvania use Lake Superior ore and this number is rapidly multiplying because the iron masters find that it is more economical to use a rich, pure ore from a distant location, than a cheap but impure one of the neighborhood of the furnaces.

From such facts it proves sufficiently, that the fame of the Lake Superior ore is a well supported one. But in comparing the same with the state of affairs in Indiana, we may say, that every point of the block coal field is far more favorably situated than any of those iron establishments throughou Pennsylvania or Ohio. Favorable points in Clay county coal fields are about 180 miles from Chicago.

Taking the same cost for mining..........................	$2 00
Transportation from the mines to Escanaba (62½ miles at 1⅓c per ton a mile)............................	83
Transportation from Escanaba to Chicago per 1 ton...	1 00
Transportation from Chicago to Clay county, Ind......	2 40
	*$6 23

*This estimate is, comparatively correct, but the freight and ores may now be had for something less. From Terre Haute to Chicago the distance is 183 miles. From Indianapolis to Chicago it is 194 miles; and from Indianapolis to Michigan City where Lake Superior ores may be had as cheap as at Chicago, the distance is 154 miles by rail.—E. T. C.

This would be a price for which the ores can be put on market at the locality named, enabling the Indiana iron-master to produce not only a good iron, but also an iron as much cheaper as the freight from Cleveland to the furnaces in Ohio or Pennsylvania.

Having spoken thus far only of the manufacturing of iron with Lake Superior ores and block coal, it remains also to mention the distribution of ores in Indiana.

Of the ores of Parke County, says Prof. Cox in his Geological Report, the banded and kidney ores are abundant throughout the county, and they are estimated to yield about 30–33 per cent. of metallic iron. Very good natured clay iron ores are also found at different creeks of this and other counties, which Prof. Cox classifies in the following manner:

1. The impure carbonate of iron, including clay iron stones, in flattened spheroidal masses and in bands, more or less continuous, associated with argillaceous shales.

2. Brown sesquioxides or limonites.

3. Silicious oxides.

The ores indicate sufficient richness to justify smelting, whenever facilities can be had for cheap and ready transportation. Especially do they show that the country has the desirable ore for admixture with those of Lake Superior and Missouri.

Close to the block coal fields we have, thirdly, the well known Iron Mountain ores of Missouri. These ores, forming veins in the crystalized slates, contain in the average:

Peroxide of iron	40.97	per cent.
Sesquioxide of iron	46.60	per cent.
Silica	7.28	per cent.
Alumina	5.45	per cent.
	100.39	

There is also the red hematite from Pilot Knob, the constituents of which are:

Sesquioxide of iron	84.85
Silica	10.41
Alumina	5.64
	100.90

It would be of no use to give here a more precise description ot the ores of Missouri, for every one interested in the matter knows that large deposits of specular and brown hematite exist, and are mined upon, in the vicinity of the Maramec river, in Phelps and Crawford counties.

The Pilot Knob bears large quantities of silicious specular ore, while the magnetic ores are found in Shephard's mountain.

According to Prof. Foster a ton of these ores can be delivered at Terre Haute, 15 miles only distant from the seams of the block coal field, at a cost of $2.20.

In the blast furnaces, rolling mills, etc., block coal has had a thorough and severe test, as I said before, and I may add here, that it is highly preferable to coke. Coke, as stated above, is considered now the best reducing agent in the fabrication of Spiegeleisen, but the producing of coke involves a great economical loss. The volatile matter of the coal is to its greater portion wasted, and while on the one hand the coal loses in coking about 30–35 per cent of its weight, the expenses are multiplied on the other.

Practical working at Carondelet has shown that the quality of the iron made by the use of block coal, is very superior to any produced in the United States for Bessemer steel making.

Trials made in the large furnaces of the Vulcan Iron Works at St. Louis, where the charges of the furnace were composed of 2,000 lbs. of block coal and Iron Mountain ores, the temperature of the blast ranging from 750° to 800° F., resulted in a foundry pig. No. I.

It is believed that blast furnaces of a far greater cubical capacity than those used now, will prove especially valuable.

Finally, I may say that, according to Prot. Foster, the Staab coal of Spencer county, Indiana, on account of its extreme hardness and its absolute freedom from deleterious substances, will, no doubt, prove peculiarly valuable as a fuel for furnaces of great dimensions.

These facts, compared with those related to above, under Russia, Sweden and Germany, there can be no doubt that the pig iron made of Lake Superior, Indiana and Iron Mountain ore, with Indiana block coal, will be not only able to compete with English, used now as an admixture by the Bessemer steel manufacturers, but that it will be even of a far better quality. Those interested in the matter may earn great profits, and the proposed plans to erect Bessemer works in Brazil, or Indianapolis, must be considered as enterprises, based upon the most sound ground.

GEOLOGICAL REPORT.

By reference to the report of my Assistant, W. W. Borden, it will be seen that from six to ten bands of manganiferous iron-stone have been traced over a very large area in the counties of Clarke and Floyd, occupying a geological position in the gray and greenish shales immediately over the "New Albany Black slate." These ore-bands are found also in Scott and Jennings counties but the extent of territory which they occupy, in the latter counties, remains to be determined by the survey, hereafter to be made.

These ore-bands are enclosed in twenty to twenty-five feet of soft shale and are from two to three feet apart and are from two and a half to ten inches thick. The readiness with which these shales decompose, under the influence of drainage water and atmospheric agencies, has given rise to numerous cone shaped hills commonly called "Knobs" and from this circumstance, also, geologists have given to the rock strata of which they are composed, the name of "Knob Shales" "Knob Sandstone," Limestone ete., so that we may, with like propriety, designate the ore as knob iron ore.

A black, bituminous shale, similar to that underlying this ore is found in Ohio occupying a similar position with reference to the under and overlying rocks, and Dr. Newberry, State Geologist of Ohio, has referred it to the Genessee epoch, but not feeling quite sure as to the accuracy of the conclusion to which this able geologist and paleontologist has arrived, I have thought best to speak of it, in this State, as the New Albany Black Slate.

Near the city of New Albany Dr. Clapp bored through

this bed of bituminous slate and found it to be one hundred and ten feet thick. It is being constantly mistaken for the bituminous shale which is often found associated with stone coal and it is a difficult matter, in all instances, to convince the people, living within the vicinity of its outcrop, that it will not turn to coal if followed to a distance in the hills. It contains from ten to twenty per cent of volatile matter and there are found in the deposit in places, thin bands of coal from a half to one inch thick. Dr. Newberry thinks that these shales derived their bitumen from sea weeds, and calls attention to the fact of finding in them vast quantities of fucoidal impressions. So far we have only succeeded in finding in the New Albany black slate a few small Lingula and Decina. In Clarke county there is resting immediately on the top of the black slate, about four inches of hard, greenish, mottled limestone and this is succeeded by the gray argillaceous shales with bands of iron stone alluded to above. There are also found resting on the black slate large trunks and limbs of coniferous trees, the vegetable matter having been replaced by silica in the form of black flint. Specimens of this fossil wood have been placed in the hands of the eminent fossil botanist Prof. Leo Lesquereux, of Columbus, Ohio, for determination and they will be figured and described in some of the forthcoming volumes. A portion of one of these petrified trees, fifteen feet long and two and a half feet wide has been placed in the Indiana Exposition building. Specimens of fossil wood are also found at the same horizon in the black slate at Delphi, Carroll county, Indiana.

Owing to the extensive washes which have cut through the shales the iron-stone is exposed in a great many places throughout the Knob region, and it may be mined or collected, from the ravines already weathered out, at a small cost. Samples from nine distinct bands have been tested for iron, and a complete analysis was made of the bottom and middle bands with the following result:

Analysis of iron-stone from near Henryville, Clarke county, Indiana, (No. 10) bottom band, two and a half inches

thick; gray, streaked with greenish lines; outside covered with oxide of iron, which was excluded from that analysed:

Silicic acid	7.300
Per-oxide of iron	2.128
Prot-oxide of iron	34.700
Prot-oxide of manganese	8.940
Alumina	1.100
Lime	5.824
Magnesia	3.027
Sulphur	.254
Phosphorus	.321
Carbonic acid	29.500
Combined water and loss	6.906
	100.000

Metallic iron, 28.48

Analysis of iron-stone from Stewart's farm, near Henryville, Clarke county, Indiana, middle band or 5th from the bottom; four and a half inches thick; of a bluish gray color with an outside coating of red oxide of iron from one-eighth to one-quarter of an inch thick. The latter was excluded from the portion analysed.

Water, @ 212°F	.500
Combined water and organic matter	4.575
Silicic acid	9.300
Per-oxide of iron	2.042
Prot-oxide of iron	35.600
Prot-oxide of manganese	6.628
Alumina	3.600
Lime	7.168
Magnesia	4.612
Sulphur	.274
Phosphorus	.340
Carbonic acid	24.925
Loss and undetermined	.436
	100.000

Metallic iron, 29.12.

In addition to the two very complete results of analyses of this ore, given above, seven other samples, from as many different bands, were tested for iron with the following results, the numbers give the order of succession, No. 1 being the top layer or band, and No. 10 the lowest:

Band No. 1 gave 26.41 per cent. metallic iron.
Band No. 2 gave 26.66 per cent. metallic iron.
Band No. 3 gave 30.51 per cent. metallic iron.
Band No. 4 gave 28.20 per cent. metallic iron.
Band No. 5 gave 29.12 per cent. metallic iron.
Band No. 6 gave 29.74 per cent. metallie iron.
Band No. 7 gave 29.23 per cent. metallic iron.
Band No. 8 gave 27.17 per cent. metallic iron.
Band No. 10 gave 28.48 per cent. metallic iron.

From this it will be seen that the raw ore contains from 26.41 to 30.51 per cent. of iron, and, from the complete analyses of the bottom and middle band, from 5.124 to 6.928 per cent. of the metal manganese.

This class of ores should always be roasted before they are thrown into the blast furnace in order to expel the hygroscopic and combined water and gases. The "Knob ore" will loose about one third of its weight by roasting and the percentage of iron and manganese will be correspondingly greater in the calcined ore so that we have in one hundred parts:

Iron..	39.81 to 47.48
Manganese................................	7.72 to 10.44
Silica......................................	11.00 to 14.02

The average per cent of combined iron and manganese in the calcined ore is 52.72 per cent, consequently two tons of such ore will make a ton of pig iron. The great value which attaches to these ores is mainly due to the large per cent of manganese which they contain, and if properly treated in the smelting furnace they will yield a highly manganiferous pig iron, if not a true spiegeleisen, which

metal is found to be indispensable in the manufacture of Bessemer or pneumatic steel.

It will be seen, by reference to the preceding articles, by Hugh Hartmann, on the manufacture of Spiegeleisen in Rhenish Prussia, that the peculiarity of this valuable metal consists in its crystalline structure, due to the manganese which it contains and to a special treatment which it undergoes by adjusting the heat of the furnace and prolonging the time of its cooling after it enters the moulds. The value of a speigeleisen is dependent upon the quantity of manganese which it contains. From 7.5 to 10.0 per cent is of very fair quality.

This per cent of manganese is fully within the capabilities of the Knob ore.

ON THE USE OF RAW COAL IN THE BLAST FURNACE.

Since there has been, in my opinion, a general misunderstanding with regard to the coking properties of the Indiana Block-coal, and of its behavior in the blast furnace, I will add here the conclusions to which I have arrived from investigating this subject, all-important to the manufacturing industries of Indiana. There is a remarkable difference between the caking coal and the non-caking or block coal, both in regard to their physical structure and in the manner of their burning. The latter has a laminated structure, burns without melting and under ordinary treatment makes a soft, poor coke. Whereas the former coal when ignited becomes soft and runs into a mass and ordinarily will make a good, strong coke. Between the extremes of these two well marked varieties of bituminous coal there are many grades of differences and they blend so closely into each other, that it is only as we approach the ends of the chain that a decision can be made without a crucial test as to which variety the specimen under examination belongs. By the ultimate analyses we find no greater variation in the per cent of the contained elementary constituents than is to be found in the different specimens of the same variety of

coal. As a means of classification and detection, then, we must look to their physical structure and to their behavior when burning or subjected to the process of conversion into coke. In the laboratory the usual mode of testing the coking properties of a coal is to determine its proximate constituents. This is usually accomplished by drying a weighed portion of the coal, in a hot air bath, for thirty or forty minutes, at a temperature of 212°F.; the loss of weight gives the per cent of hygroscopic water; the residue is burnt and the per cent of ash is found by weighing the incombustible earthy matter. Another portion is placed in a covered platinum crucible and heated to a bright red heat over the gas flame to expel the volatile matter, the loss gives the per cent of gas plus the water determined by the first experiment, and the weight of the charred mass represents the per cent of coke. The per cent of fixed carbon is found by deducting the ash from the coke.

Analysed in the above manner there is a marked difference in the behavior of the two varieties of coal. The particles of the caking coal are fused by the heat applied to the crucible and run into a hard amorpous mass more on less porous and of a steel gray color. On the other hand the block coal does not change form at all, the charred pieces have not melted or fused together and the finer particles may be poured out of the crucible like so much sand.

In order to test the effect of pressure on the quality of the coke, ten grammes of coal, in coarse powder, were coked in a small cast-iron retort with a quarter inch discharge pipe leading from the top into a strong two necked Woulfe's bottle which served as a tar well, from this the gas was carried through a washing bottle and then discharged at the bottom of a tall glass cylinder capable of holding a column of mercury twelve inches in hight without danger of its being thrown out at the top by the force of the escaping gas.

The tabulated results, are given below, of a number of coals charred in the usual way adopted by chemists, in making the proximate analysis of coal, and in the iron

retort arranged as above first without pressure and then with pressure formed by adding mercury to the graduated cylinder. The greatest pressure attained was that from a column of mercury twelve inches high or little more than a third of an atmosphere. The crucible was heated to an almost white heat by the uniform flame of a three-jet Bunsen gas burner. The gas which supplied the flame issued under a pressure of one and a half inches of water. The analyses were made, under my direction, by my Assistant Dr. G. M. Levette, whose skill and attention to the work gives assurance of its accuracy.

The Pittsburg coal, tested for coke, was from Stone's mine, and I regret being unable, at the time, to procure a specimen of Connellsville coal, so celebrated for the excellence of its coke ; but since the object of the experiments were to prove the effect of pressure in increasing the density and per cent of coke, it matters but little as to the particular coals used.

The weight of coke obtained when the coal is charred in the iron retort varies according to the character of the specimens treated; with some the gain is but little more than we find by the proximate analyses as usually made in a platinum crucible, while in others, the Sullivan county and Pittsburg coals, the increase of coke is nearly ten per cent, as may be seen by the subjoined table:

COALS COKED UNDER DIFFERENT DEGREES OF PRESSURE.

NAME OF MINE OR OWNER.	Platinum crucible. Proximate analysis.	Iron retort. No mercury.	Iron retort. 3 inches mercury.	Iron retort 6 inches mercury.	Iron retort. 12 inches mercury.
No. 1. H. K. Wilson, Sullivan, Co., Ind.	52.40	59.10	62.00	62.80	59.40
2. Simonson's, Knox Co., Ind	52.50	54.35	54.00	54.30	56.50
3. Shepard & Haslett's, Knox Co. Ind	55.50	56.10	56.40	57.95	56.15
4. Woodruff & Fletcher, Clay Co. Ind	57.50	58.85	60.40	58.50	59.25
5. Barnett's, Clay Co., Ind	58.50	62.20	61.75	62.60	63.40
6. Stone's, Pittsburg, Pa	57.90	65.05	65.00	65.10	66.10

H. K. Wilson's coal (No. 1) was tested with other degrees of pressure not enumerated in the above table; one-half inch of mercury, 62.10 per cent of coke; one inch mercury, 61.50 coke; two inches mercury, 60.50 coke; five inches mercury, 61.80 coke; amd with one inch of sand resting directly on the powdered coal in the retort, no other pressure, gave a close grained compact coke, but the percentage could not be accurately determined on account of numerous grains of sand which adhered to the coke.

Nos. 1, 2, 3 and 6, of the table, are caking coals, No.'s 4 and 5 are non-coking or block coals.

The coke from No. 1 made in the retort, without pressure, was moderately firm, close textured, of grayish black color and without lustre; with a pressure exerted by a column of water four inches high (not given in the table) the coke was not increased in weight, but appeared more compact and presented a radiated, crystalline structure, the the rays run from a small central core to the circumference. This peculiar structure was lost when the pressure was increased. Up to a six inch pressure of mercury there was a gain of 3.7 per cent of coke which was very dense and strong. At 12 inches of pressure the per cent of coke was scarcely more than that obtained without pressure and it gave signs of puffing. From this it will be seen that 6 inches of mercury gives the maximum per cent of coke and that beyond this the heat is sufficient to liquify the fixed carbon and expand its particles so as to make a puffed, porous cake. With a half inch of mercury pressure, after the gas had ceased to come over and the washing flask was detached, the pent-up gas would escape from the retort with so much force as to make a loud whistling noise in rushing through the open neck of the Woulfe bottle; the greater the pressure the louder and more prolonged the noise. There was little difference in the time occupied in coking with or without pressure. The average time was forty-five minutes.

Instead of the powdered coal, some pieces, a little larger than a pea, were coked under 6 and 12 inches pressure and they were found unchanged in shape except that the edges

were slightly fused and they were cemented together like a pop corn ball. The color and appearance of the pieces resembled anthracite coal far more than coke. Under 12 inches pressure the pieces were slightly swollen, but in color and structure otherwise presented the same appearance as the former.

The effect of pressure on the Pittsburg coal, No. 6, was quite different and equally as remarkable.

The weight of the coke continued to increase up to a pressure of 12 inches where it gained 8.2 per cent over the result in the 1st column, but it was puffed up until the shape resembled a hen's egg and contained a large cavity in the centre of the mass. The fracture presented also a cellular structure like a sponge. Without any pressure this coal gave a moderately dense coke but continued to puff up with every inch of pressure added.

The two caking coals from Knox county, No.'s 2 and 3, gave a cellular coke without pressure and the cells, were only slightly enlarged by twelve inches of pressure, and the weight of the coke in No. 2. at twelve inches was increased by 4 per cent, and that of No. 3 by only 0.65 per cent, while under six inches pressure the increase was 2.45 per cent.

Though these coals do not puff up, under pressure, as much as the Pittsburg coal; the result clearly points out that all three belong to a class of coals that will not make a good coke under pressure, but that the coking oven, like the retorts at the gas works, should be subjected to a process of exhaustion. The coke made from Pittsburg coal in the gas retorts is very close and strong.

No. 4. Woodruff & Fletcher's block coal, Clay county, coked without pressure, gave a coke that possessed but little cohesion; as the pressure increased the coke was more compact, and under twelve inches pressure it was strong and good; the color, like that of No. 1, resembled anthracite rather than coke; the greatest increase was produced by pressure of twelve inches and only amounted to 1.75 per cent.

Barnett's coal, No. 5. This is one of the driest burning of

the block coals and the particles were but slightly coherent even under a pressure of twelve inches, the increase in weight, at this pressure, amounted to 4.9 per cent.

The greatest pressure exerted on the block coals did not cause the carbon to become liquid as in the caking coals and the particles were simply cemented together by fusing on the surface. Lumps, when coked under pressure, do not therefore swell, but rather become more dense and homogenous with an increase of heat.

Though the above experiments are not as complete, in many respects, as they should be, I look upon this mode of testing coals as destined to furnish important information with reference to their coking properties and to their behavior in the blast furnace. It appears that in order to make a homogeneous good coke the fixed carbon of the coal must be of a kind that will melt at the lowest possible temperature, for if the process of coking produces the least pressure on the volatile hydrocarbons, whereby there is an increase of heat, such pressure causes so complete a liquifaction and expansion of the fixed carbon that the coke is left cellular instead of being compact. If such a coal is coked by covering it with an inch of sand and leaving the cover of the retort off, the coke will be dense and strong and without cells that are perceptible to the eye. On the other hand, coals, like the block coal of Indiana, which requires a very high temperature to melt its fixed carbon, does not have its coke expanded by heat induced by an over pressure of the eliminated gas, but as far as tried in the above experiments, the solidity of the block coal coke increased as the pressure was augmented by raising the column of mercury through which the gas had to escape; such coals, then, are eminently adapted, in the raw state, for smelting iron in the blast furnace. The closed top blast-furnace, with flues for conducting the waste gas produced by the combustion of the carbon and the distillation of the volatile hydrocarbons of the raw coal, presents similar conditions for the coking of the coal before it reaches the zone where it is ignited by the blast, to that given by the crucible tests without mercury

pressure, but with a covering of sand. The latter materially increased the density of the coke and corresponds to the pressure that is exerted by the burden of the furnace. The blast furnace in which iron ores are smelted may be compared, in form, to two truncated cones joined at their bases; it is filled with alternate layers of fuel, ore and limestone. In the lower part or crucible of the great shaft a rapid combustion of the fuel is accomplished by means of a blast of heated air, which is sent in at the hearth with great force through a number of pipes called tuyeres. The heat thus produced fuses the inorganic substances and the iron, separated from the slag by its gravity, falls to the hearth at the bottom of the crucible and is finally run out into long bars called pigs. The chemical combination of the oxygen of the blast with the carbon of the ignited fuel, whether that be charcoal, coke or raw coal, forms, probably in the first instance, carbonic acid (C. O. 2.); but, investigation goes to show, that the permanent gas formed in this zone of the furnace is carbonic oxide, (C. O.) diluted with a large amount of nitrogen derived from the atmosphere. The gases thus formed ascend through the solid contents of the shaft to which they yield up a portion of their heat. In this way there are two currents established in the furnace, an upward current of heated gas which gradually parts with its heat as it ascends, and a descending current of solid minerals, which are cold when thrown in at the top, but become hotter and hotter in their descent until finally fused at the hearth. The carbonic oxide of the ascending current partly reduces the ore, which is in the condition of a peroxide of iron, by depriving it of a portion of its oxygen, so that before the gas leaves the top of the shaft a portion has been changed to carbonic acid. This deoxidizing of the ore, by carbonic oxide only, takes place under certain conditions and the amount of change is, at best limited. One of the most essential conditions to promote this action is the presence of moisture. The change thus made in the ore renders it porous and favors its final reduction. It is therefore an object of very great

economical importance to obtain from the ascending gas all the chemical effect which it is capable of producing, both in the way of absorbing the oxygen from the ore and in heating the furnace before it is carried out of the top of the stack and further utilized in heating the boilers and blast-ovens. With a view to accomplish this end, very high furnaces have been built and the temperature of the blast air has been increased, and in both instances, within certain bounds, favorable results have been obtained.

INDIANA BLOCK COAL

is of itself very strong and able to bear up as much burden as coke, but it is, by the heat in the upper part of the furnace, converted into a dense coke before it meets the blast where it enters into perfect combustion. That my readers may comprehend the important part performed by the blast, I will state that more than five tons of air are required for every ton of pig iron smelted. From the fact that the raw coal is changed to coke before it is burned, the effect produced by the two fuels, coke and raw coal, are the same in the zone of fusion, and it is only in the upper part of the furnace that we must look for dissimilar effects. Here the raw coal is gradually heated and the hydrogen and hydro-carbons, which form about forty parts of its substance, are distilled off and the gaseous contents of the shaft are, consequently, about thirty-seven per cent greater than when coke is the fuel; it follows therefore that if the size of the throat and gas flues are properly adjusted for coke, they must be made, at least, one third larger for raw coal If this point is not attended to the furnace must lose heat, through want of perfect combustion, run irregular, and consume vastly more fuel per ton of pig iron made.

Mr. I. Lothian Bell, in his valuable work on the Chemical Phenomena of the blast furnace, says that "raw coal in the blast furnace requires the extra heat produced by fifteen pounds of coke, for every 100 pounds of coal, to expel the volatile matter, or in other words, to coke it, and its reducing powers are diminished consequently in that

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proportion." Mr. Bell arrives at this conclusion by ascertaining that fifteen pounds of coke are burned under the retorts, at the gas works, for expelling the gas from 100 pounds of coal, and he estimates the calories of coal and coke to be about the same. A similar showing is made if we reason from the process of making coke in ovens. Here the heat necessary for distillation is derived from the expelled gas, and of that one third only is required for the operation and the other two thirds are wasted for want of means to utilize it.

Under the most favorable management at Cleveland, in in the north of England, twenty two and one-half hundred weight of coke will smelt one ton of pig iron from Cleveland iron stone. This ore is a lean carbonate of iron, very similar in composition to the Clarke county, Ind., ore. Twenty two and five-tenths hundred weight, or 2520 pounds of coke will correspond to 3360 pounds of block coal, and I have no doubt but that, when we have discovered the proper form of furnace and the best mode of preparing the stock at our command, less than two tons of block coal will be required to make a ton of pig iron.

The loss of heat by absorption, when raw coal is used in the blast furnace, is more than compensated for by the highly deoxidizing action of the hydrogen and hydrocarbons in which the ore is so comepletely bathed. The amount of oxygen absorbed from the ore by carbonic oxide, when the fuel is coke, reaches, under favorable conditions, about thirty per cent of the entire oxygen which it contains. Now, there is no reason why this reducing action of carbonic oxide should not proceed to completion if those aids which facilitate the reduction are present in sufficient quantity.

It has been proven by investigation that moisture must be present to promote this favorable action of carbonic oxide and, indeed, it is mentioned by some that the process of deoxidation cannot take place in the furnace without it. Raw coal supplies this essential constituent (H.O.), together with hydrogen (H.) in far greater abundance than coke; and since hydrogen is a much better deoxidizer than carbonic

oxide, and the hydrocorbons themselves being almost as good absorbents for oxygen as the latter gas; I have every reason to believe that, when used under the most favorable conditions, we will obtain as large yields of iron with the Indiana block coal fuel as can be obtained from the same ores with coke, and the quality of the iron will be superior to that made with the latter fuel.

I am satisfied that most, if not all of the difficulties, experienced by the cooling and irregular working of the raw coal furnaces in this State, come from a want of sufficient sized outlet at the throat for the waste gases, for it must be borne in mind that the heat of the furnace, within certain bounds, depends upon a good upward draft.

HYDRAULIC CEMENT.

The manufacture of hydraulic cement constitutes one of the most important industries of Clarke county. No less than six mills are engaged in this branch of manufacture and the cement is shipped to all parts of the western and southern States and sold under the name of "Louisville Cement." The rock from which it is made is of the Devonian age and belongs to the corniferous epoch. It is in three layers and has a total thickness of fifteen to twenty-five feet. It crops out on both banks of the Ohio river at, and opposite, the ancient village of Clarksville, about two miles below Jeffersonville, and is exposed along the banks of Silver creek and its tributaries, to the northward, for a distance of fifteen miles or more. There are crops also in the neighborhood of Charlestown. The district which it occupies is included within the boundaries of the space numbered 4 on the map accompanying this volume.

The cement rock is again seen in Scott and Jennings counties, and will probably be found in Jackson, Decatur and other counties in this part of the State that have not yet been surveyed. It makes its appearance on the Wabash river in Wabash county, and near to the town of that

name. At the latter locality it has been burnt and made into cement, and there are a number of cisterns in Wabash town that were lined with it, which have, so far as known, stood well and given good satisfaction. The analysis of the Wabash cement stone, collected from a bed ten to twelve feet thick, on the Davis farm near Somerset, Wabash county, has the following composition in one hundred parts of stone:

Moisture at 212° F.	1.000
Silicic acid	30.600
Alumina	16.720
Carbonate of lime	25.600
Carbonate of magnesia	12.713
Carbonate of iron	2.480
Organic matter, alkalies undetermined and loss	10.887
	100.000

Another sample from a seam five to ten feet thick, on Helm creek, two miles west of Wabash town, contains:

Moisture at 212° F.	2.000
Silicic acid	34.200
Carbonate of lime	28.000
Carbonate of magnesia	3.117
Carbonate of iron	1.242
Alumina	18.760
Loss and undetermined	12.681
	100.000

On Chapelle creek, LaGros, Wabash county, the seam is ten to fifteen feet thick, and contains:

Moisture at 212°F.	1.80
Silicic acid	35.60
Alumina	17.86

Carbonate of lime	26.00
Carbonate of magnesia	2.42
Carbonate of iron	4.14
Loss and undetermined	12.18
	100.00

Judged by their composition these stones should make a good hydraulic cement.

It is well known that stone of very dissimilar composition, as regards the amount of lime, magnesia, silica and alumina which they contain, make equally good hydraulic cement.

Indeed by a proper admixture of argillaceous stone and sand with "fat" lime the very best quality of hydraulic cement may be made. Pure limestone, after being calcined, will absorb 22 to 23 per cent of water and passes into the condition of hydrate ot lime. The union is attended with great elevation of temperature and the lime breaks or is slaked into fine powder. On account of its affinity for water and carbonic acid, lime will absorb these substances from the atmosphere and gradually assume, under certain conditions, by returning to carbonate of lime, a stone-like hardness.

When lime is found mixed with impurities such as silica, alumina and magnesia, or when these are added to it in proper proportions it acquires the property of hardening under water, or when excluded from the air. Cements made in this way are used for the construction of masonry under water, building cisterns that are designed to hold water and for cementing all manner of mason work where the walls are exposed to dampness.

Hydraulic properties, or the property of hardening under water or in moist places, may be imparted, in a like perfect manner, to lime by admixing any of the above materials in proportions widely differing from each other. A knowledge of these facts, regarding the hardening of morter

composed of an admixture of clay, lime, sand and gravel or fragments of stone, extends back to a period so remote that history can furnish no clue to its origin.

Common lime contains but a small amount of impurities, rarely as much as ten per cent; morter made of it alone will not harden under water, or in damp places if excluded from contact with the air. In the air it will dry and harden, but shrinks to such a degree that it cannot be used for building purposes without a large quantity of sand. Common morter used for building purposes is, therefore, composed of "fat" lime and sand.

Puzzuolana is the name of a hydraulic cement known to the Ancients and was employed in the marine constructions of the Romans. Puzzuolana derives its name from the village at the foot of Mt. Vesuvius where it was first discovered; it is is of volcanic origin and when mixed with sand and lime makes a durable hydraulic cement. Vitruvius gives the following formula, which is still very generally followed, for making this cement: *

Puzzuolana, well pulverized	12 parts.
Quartzose sand, well washed	6 parts.
Rich lime, recently slaked	9 parts.
Fragments of broken stone	6 parts.

It is not alone in Europe that we find a well founded claim of high antiquity for the art of making hard and durable stone by a mixture of clay, lime, sand and fragments of stone; for I am satisfied that this art was possessed by a race of people who inhabited this continent at a period so remote that neither tradition nor history can furnish any account of them. They belonged to the Neolithic or polished stone age. They lived in towns and built mounds for sepulture and worship, and protected their homes by surrounding them with walls of earth and stone. In some of these mounds specimens of various kinds of pottery, in a perfect state of preservation, have from time

* See Hydraulic Cement and Mortar's. Maj. Gen. Gillmore.

to time been found, and fragments are so common that every student of archæology can have a bountiful supply. Some of these fragments indicate vessels of very great size. At the Saline springs of Gallatin county, Illinois, I picked up fragments that indicated, by their curvature, vessels five to six feet in diameter, and it is probable that they are fragments of artificial stone pans used to hold brine that was manufactured into salt by solar evaporation.

Now, all the pottery belonging to the mound-builders, age, which I have seen, is composed of alluvial clay and sand or a mixture of the former with pulverized fresh-water shells. A paste made of such a mixture possess in a high degree the properties of hydraulic Puzzuolana and Portland cement, so that vessels formed of it hardened without being burnt as is customary with modern pottery. The fragments of shells served the purpose of gravel or fragments of stone as at present used in connection with hydraulic lime in the manufacture of artificial stone. It will be seen by the following analysis of a piece of ancient pottery from the "Bone Bank" in Posey county, Indiana, that, so far as chemical constituents are concerned, it agrees very well with the composition of hydraulic stones, and for the purpose of comparison I subjoin the analyses of natural Portland cement from Boulogne, France; artificial Portland cement from London; Rosedale cement stone from New York; Cumberland cement stone from Maryland and Balcony Falls cement stone from Virginia, copied from "A Practical Treatise on Coignet-Breton and other artificial Stone" by Maj. Gen. Q. A. Gillmore, pp. 12 and 13, and the Clarke county, Indiana, Hydraulic limestone, the analysis of which was made in my laboratory:

Ancient Pottery, "Bone Bank," Posey Co., Indiana:

Moisture at 212° F.	1.00
Silica	36.00
Carbonate of lime	25.50
Carbonate of magnesia	3.20

Alumina	5.00
Peroxide of iron	5.50
Sulphuric acid	.20
Organic matter, alkalies and loss	23.60
	100.00

Boulogne Portland cement, (natural):

Lime	65.13
Magnesia	.58
Silica	20.42
Alumina and a small quantity of oxide of iron	13.87
Sulphate of lime	trace.

London Portland cement, (artificial):

Lime	68.11
Silica	20.67
Alumina	10.43
Oxide of iron	.87

Rosedale cement stone, (New York):

Carbonate of lime	46.00
Silica, clay and insoluble silicates	27.70
Carbonate of magnesia	17.76
Alumina	2.34
Peroxide of iron	1.26
Sulphuric acid	.26
Chlorides of potassium and sodium	4.02
Hygrometric water	.22
Loss	.44
	100.00

Cumberland cement stone, (Maryland):

Carbonate of lime	41.80
Silica, clay and insoluble silicates	24.74

Magnesia	4.10
Alumina	16.74
Peroxide of iron	6.30
Soda	4.64
Potash	1.54
Sulphuric acid	2.22
Hygrometric water	.60
	102.68

Balcony Falls stone, (Virginia):

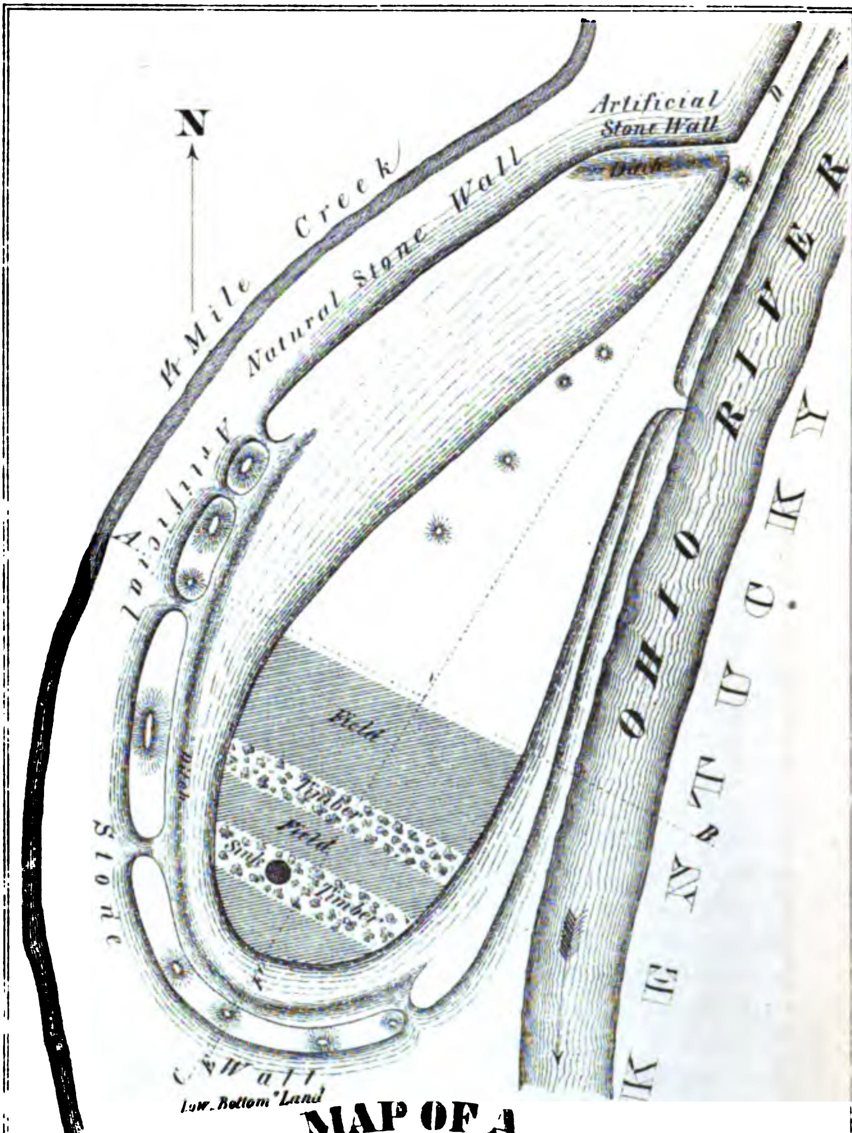
Lime	17.38
Silica	34.22
Alumina	7.80
Magnesia	9.51
Carbonic acid	30.40
Water and loss	.69
	100.00

Hydraulic limestone, Beach's Mill, Clarkesville, Clarke county, Indiana; color, ash gray; fracture, conchoidal; contains a few disseminated small crytals of iron pyrites.

Moisture at 212° F	.500
Loss by ignition, organic matter	5.000
Silicic acid, soluble	6.400
Silicic acid, insoluble	13.200
Carbonate of iron	2.548
Sulphate of iron	2.086
Carbonate of magnesia	2.631
Carbonate of potash	8.984
Carbonate of soda	3.676
Chloride of sodium	1.263
Alumina	14.573
Phosphoric acid	.195
Carbonate of lime	37.200
Loss	1.744
	100.000

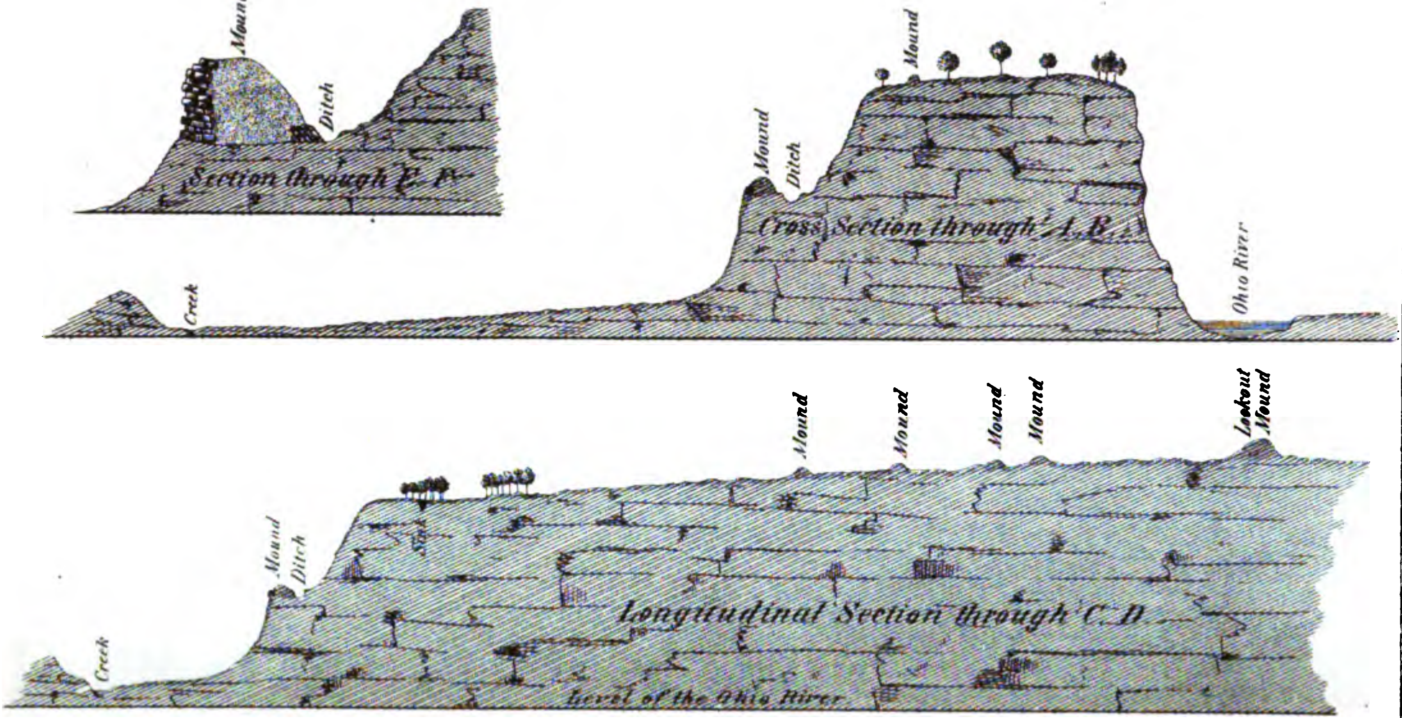
In comparing the above analyses, one with another, it will be seen that the constituents of the so called Indian pottery, Rosedale, Cumberland, Balcony Falls, Clarke county and Wabash county cements are given from the stone which has not been calcined; whereas, those of the Portland cements are given from calcined stone. The only material difference is, that the latter contains a little more lime than the American cements and will therefore admit of a larger proportion of sand or gravel, in producing from it either hydraulic mortar or artificial stone. Notwithstanding the high antiquity of the art of manufacturing artificial stone from an admixture of calcareous, siliceous and aluminous earths, there remains, still, much to be learned before such stone can be looked upon with much favor for ordinary flagging and building stone. . I am well aware that concrete is extensively used for the embellishment of some of the finest and most costly of modern buildings, both in Great Britain and on the Continent, but in many cases it was wearing badly, and at best presented but a scaly appearance by the side of ordinary natural stone.

Artificial stone formed a conspicuous feature among the other industries exhibited at the Vienna Universal Exposition. It was formed into statues, vases, building blocks, flag stones ornamented with figures formed by embedded fragments of colored stones; tile for paving courts, halls etc. The great steps, in the hotels, are made of concrete and on every story the halls are laid with it. Fine brick buildings are adorned, on the outside, with a coating of concrete, which formed a cheap imitation of stone; but do what they would the sham was prominently apparent and the walls require patching, annually, to keep up a respectable appearance. During the holding of the Exposition there was so much building going on in Vienna, and the use of concrete, made of Portland cement mixed with sand, was carried to such a pitch, that the atmosphere was loaded with the peculiar oder of mortar, due, no doubt, in part to the elimination of ammonia from the clay. Drain tile and large pipes for sewers, similar to those manufactured by the



MAP OF A
STONE FORTIFICATION AND MOUNDS
on the Ohio River 3 Miles East of Charlestown, Clarke Co., Indiana.

Surveyed by Prof. E. T. COX, *State Geologist*
and
W. W. BORDEN,
Assistant.



Sections through the Stone Fortification and Mounds near Charlestown, Clarke Co. Indiana.

Indianapolis Pipe Manufacturing Co., and made of cement, were also on exhibition, but I saw no large pipes that were as smooth and free from cracks as those made in this city. The climate of Europe appears to be less trying on the durability of artificial stone than that of America, and to this may be added a possible better knowledge of the art of manufacturing; these may be the reasons for its general good favor there and discredit here.

I do not, however, wish to be understood as endeavoring, by the above remarks, to disparage the entire use of artificial stone, but rather as pointing out its present defects to encourage the use ot a better article which, I am sure, from the nature of the chemical reaction which takes place between the component parts, can be made when a more perfect knowledge of the subject is acquired; nor can I see why the Portland cement should have preference over that made in Clarke county and sold in the market under the name of "Louisville Cement."

It would be advisable, if the proper apparatus can be furnished by the State, to institute a series of experiments for determining the hardness and strength of stone or hardened mortar made of the various hydraulic stones which occur in such abundance in Indiana, and from which a large annual revenue is derived. These investigations, if properly managed, will furnish a vast amount of useful information in regard to the selection of the stone and its subsequent treatment to insure uniform results and a superior article of cement. Such an apparatus will also serve for testing the strength of stone, its resistance to a crushing force, the tensile strength of iron, etc., etc.

MOUNDS AND MOUND BUILDERS' IMPLEMENTS.

No departmeut of natural history appears, at this time, to attract more general interest than that which ralates to pre-historic man; nor is this to be wondered at, for, go where you will in the extensive valley of the Mississippi and other portions of the United States, south of the great lakes, you will meet with numerous mounds and earth and

stone wall enclosures. Many of these mounds vie with the pyramids of Egypt in magnitude and, when taken in connection with the walls of earth and stone which have been thrown up to enclose large areas of country, bear evidence of a powerful nation, which in numbers may have equalled, if they did not excel, the present population of the Mississippi valley.

No written history or puzzling hieroglyphics have been left behind, nor could any reliable account be obtained from the savage races who were found in posesession of the country by the earliest white explorers, that could give any clue to the antiquity of these mounds and walled enclosures. To them, all was as inexplicable as to us. They found growing on the mounds large forest trees, and the earth-works presented then, as now, evidence of decay and great age.

The tumuli and walled enclosures of this pre-historic people whom we call mound builders for want of knowledge of their true natural name, are found in the greatest numbers situated mostly on the first and second river terraces and seldom, on the low bottom land along the large rivers and their principal tributaries. This has led many to infer that the rivers have since the time of the mound builders, narrowed and changed their channels, within an area equal to the width of the present alluvial bottoms.

The extent and magnitude of the works executed by these people, lead to the inference that they lived in towns and were governed by a despotic ruler whose will was law and whose commands received implicit obedience.

Their food consisted principally of the flesh of all kinds of animals, as may be seen by the bones which are found in the refuse piles from their kitchens.

Fresh water bivalves (Unionidæ) and univalve mollusks were also consumed in such quantities that great banks of shells, miles in length, are left to mark the places where, it is possible high carnivals were held over fresh water "Clam-bakes."

At Clarksville, just below the falls of the Ohio river, in

Clarke county, there is a shell heap extending for a mile or more up and down the river. This locality must have been a favorite place of resort; an ancient Long Branch where it was possible to find enjoyment and pass a pleasant summer catching fish at the foot of the falls, where they congregated at certain seasons of the year in such vast numbers as to become an easy prey to the bone-hooks and spears used for their capture by these pre-historic people.

In digging a foundation on the bank of the river for a new calcining kiln at Mr. H. Beach & Co.'s cement mill the excavation went through a shell heap in which Mr. Beach found a number of stone relics; a large greenstone axe highly finished; an oval shaped stone sixteen inches long, three inches in diameter in the middle and one and a half inches at each end. One of the ends is worn to a smooth conical point. It is made of corniferous limestone. A fragment of a similar instrument, broken in the middle where it is six inches in diameter was never finished, probably on account of its accidental breaking. The hammer marks produced by working it in to shape are still plainly to be seen. Along with the above instruments of stone was an awl made of a fragment of deer's bone. The shell heaps of this region have furnished to the explorers from time to time, a large number of bone fish hooks, knives, awls and other ornaments of bone, many of which are preserved in the cabinet of the New Albany Historical Society. I may add also that this society has one of the largest and most interesting archæological collections in the State.

At the mouth of Fourteen Mile Creek, and about three miles from Charlestown, the county seat of Clarke county, there is one of the most remarkable stone fortifications which has ever come under my notice. Accompanied by my assistant, Mr. Borden, and a number of citizens of Charlestown, I visited the "stone fort," as it is called, for the purpose of making an examination of it. The accompanying map, page 123, made by stepping over the ground, will serve to give a general idea of the extent and character of the work.

The locality selected for this fort presents many natural advantages for making it impregnable to the opposing forces of pre-historic times. It occupies the point of an elevated narrow ridge which faces the Ohio river on the east, and is bordered by Fourteen Mile Creek on the west side. This creek empties into the Ohio a short distance below the fort. The top of the ridge is pear shape, with the part answering to the neck at the north end. This part is not over twenty feet wide and is protected by precipitous natural walls of stone. It is two hundred and eighty feet above the level of the Ohio, and the slope is very gradual to the south. At the upper field it is two hundred and forty feet high and one hundred steps wide. At the lower timber it is one hundred and twenty feet high. The bottom land at the foot of the south end is sixty feet above the river. Along the greater part of the Ohio river front, there is an abrupt escarpment of rock entirely too steep to be scaled, and a similar natural barrier exists along a portion of the north west side of the ridge facing the creek. This natural wall is joined to the neck by an artificial wall made by piling up, mason fashion, but without mortar, loose stone, which had evidently been pried up from the corniferous layers at the point marked D. This made wall at this point is about one hundred and fifty feet long. It is built along the slope of the hill and had an elevation of about seventy-five feet above its base, the upper ten feet being vertical. The inside of the wall is protected by a ditch. The remainder of the hill is protected by an artificial stone wall built in the same manner but not more than ten feet high. The elevation of the side wall above the creek bottom is eighty feet. Within the artificial walls are a string of mounds which rise to the height of the wall and are protected from the washing from the hill sides by a ditch twenty feet wide and four feet deep. The position of the artificial walls, natural cliffs of bedded stone, as well as that of the ditch and mounds will be better understood by a reference to the accompanying map and cross sections. The top of the enclosed ridge embraces ten or twelve acres, and there are

as many as five mounds that can be recognized on the flat surface, while no doubt many others existed which have been obliterated by time and through the agency of man in his efforts to cultivate a portion of the ground. The section through E F shows the relation of the stone wall to the mounds on the south end of the ridge. A trench was cut into one of these mounds in search of relics. A few fragments of charcoal and decomposed bones and a large, irregular diamond-shaped boulder, with a small circular indentation near the middle of the upper part that was worn quite smooth by the use to which it was put, and the small pieces of fossil coral—*favosites goldfussi*—comprised all the articles of note which were revealed by the excavation. The earth of which the mound is made, resembles that seen on the side of the hill and was, probably, in most part taken from the ditch. The margin next to the ditch was protected by slabs of stone set on edge and leaning at an angle corresponding to the slope of the mound. This stone shield was two and a half feet wide and one foot high. At intervals along the great ditch there are channels formed between the mounds that probably served to carry off surplus water through openings in the outer wall.

On the top of the enclosed ridge, and near to the narrowest part, there is one mound much larger than any of the others and so situated as to command an extensive view up and down the Ohio river, as well as affording an unobstructed view east and west. It is designated on the sketch as "Lookout Mound."

There is, near this mound, a slight break in the cliff of rock which furnished a narrow passage way to the Ohio river.

Though the locality afforded many natural advantages for a fort or stronghold, one is compelled to admit that much skill was displayed and labor expended in rendering its defense as perfect as possible at all points. Stone axes, pestles, arrow heads, spear points, *totums*, charms and flint flakes have been found in great abundance in plowing the field at the foot of the old fort.

While calling attention to the remarkable works of the Mound builders in Clarke county, I desire also to say a few words about another very remarkable locality situated on the Wabash river, about ten miles above its mouth, in Posey county. It is called the "Bone Bank" on account of the many skulls and other human bones which have been washed out on the bank of the river and elicited the attention of navigators from the earliest settlement of the country to the present time.

Dr. G. M. Levette visited the "Bone Bank" last November and made the map which accompanies this report. (See frontispiece). It is situated in a bend on the left bank of the river, and the ground is about ten feet above high water mark, being the only land for many miles along this part of the river that is not submerged in seasons of high water. The bank slopes gradually back from the river to a slough. This slough now seldom contains water, but no doubt, at one time, it was an arm of the Wabash river, which flowed around the "Bone Bank" and afforded protection to the island home of the Mound builders. It will be seen, by reference to the map, that the Wabash has been changing its bed for many years, leaving a broad extent of newly made land on the right shore and gradually making inroads on the left shore by cutting away the "Bone Bank." The stages of growth of land on the right bank of the river are well defined by the cotton wood trees which increase in size as you go back from the river.

Unless there is a change in the current of the river, all trace of the "Bone Bank" will be obliterated. Already, within the memory of the white inhabitants, the bank has been removed to a width of several hundred yards. As the bank is cut by the current of the river it loses its support, and when the water sinks it tumbles over, carrying with it the bones of the Mound builders and the cherished articles buried with them. No locality in the country furnishes a greater number and variety of relics than this. It has proved especially rich in pottery of quaint design and skillful workmanship. I have a number of jugs and pots

and a cup found at the "Bone Bank," all of which will be figured in a future report. This character of ware has been very abundant and is still found in such quantities that we are led to conclude that its manufacture formed a leading industry of the inhabitants of the "Bone Bank."

I have already, on page 119 of this report, called attention to the composition of the pottery found at the "Bone Bank," and put forth the opinion, based upon the result of its analysis, that it is simply an artificial stone made from a mixture of river mud and pulverized fresh water shells. Instead of softening in water, as they would if made of clay alone, the shells give to the composition hydraulic properties, and vessels made of it harden on exposure to air and moisture. When filled with water and meat, pots made of this material could be placed over the fire and heated without fear of breaking them. Those ancient artizans must have been aware of the advantage derived from a thin body to resist breakage from expansion and contraction from the heat of the fire. I have a beautiful vessel, from the "Bone Bank," made of artificial stone, which has ears, and is otherwise formed, like an old fashioned cast iron dinner pot. It is five inches across the mouth and seven inches in diameter at the bulge, five inches deep and only one-eighth of an inch thick. The bottom is smoked black, which goes to show that it was suspended over the fire for cooking purposes.

The following memoranda were made by Dr. Levette at the time of his visit:

"The 'Bone Bank' forms the east bank of the Wabash river for fifteen hundred feet, is one hundred and eighty feet wide at the widest point near the south end, and thirty-five feet above the water at the highest point;* it is situated in sections 7 and 18, town 8 south, range 14 west,

*At the time of my visit, 15th of November, 1873, the river was very low.

in Posey county, Indiana; two and a half miles due north of the confluence of the Wabash with the Ohio river, and ten miles by the tortuous current of the first named stream."

"Within the memory of the early settlers the 'Bank' was two or three times its present width; but the current of the river, during each freshet, impinges violently on the exposed front, and will, in time, carry the last vestige of it into the river."

"Though no mounds are now visible on the top of the 'Bank,' the old settlers distinctly remember some small hillocks, or tumuli, on the southern and higher end; whether these were mounds of sepulture, sacrifice, or observation, can not now be determined. The whole surface is strewn with countless fragments of pottery, broken during the process of manufacture, or by subsequent use. There is a dwelling house on the south end, the residence of Joseph Reeves, Esq., the owner of a tract of land of which the 'Bank' is a part. He informed me that almost every post-hole, or other slight excavation made, exposed human bones and pottery."

"Formerly the 'Bank' was sparsely covered with gigantic forest trees, larger than those in the adjoining forest; but never, within the memory of white men, so densely covered with trees as the adjacent lower lands."

"The opinion held by some archæologists, that the 'Bone Bank' is a true mound, constructed of earth taken from the slough on the east side of it, can not be sustained in the face of the fact that the strata of coarse and fine sand and gravel of various shades of color, may be distinctly traced from the water's edge to within two feet of the top of the 'Bank' at its highest point, and for the whole length of it up and down the river."

ANALYSES OF IRON ORES.

County.	Name of Locality or Owner.	Water Dried at 212°.	Combined Water and Organic Matter.	Silicic Acid.	Per Oxide of Iron.	Prot Oxide of Iron.	Metallic Iron.	Prot Oxide of Manganese.	Alumina.	Lime.	Magnesia.	Sulphur.	Phosphorus.	Carbonic Acid.	Undetermined and Loss.
Clarke......	Near Henryville, lower band....................	.50	....	14.30	....	35.98	28.00	7.44	1.60	6.82	3.20	.055	.559	....	29.646
Clarke........	Near Henryville, bottom band, No. 10......	....	....	7.30	2.128	34.70	28.48	8.94	1.10	5.894	3.027	.354	.321	29.50	6.906
Clarke........	Near Henryville, Stewart's, No. 5............	.50	4.575	9.30	2.042	35.60	29.12	6.628	3.60	7.168	4.612	.274	.340	24.925	.436
Clarke........	Medzker's..	.50	22.50	16.00	....	40.00	31.11	8.00	2.50	18.00	13.20	2.10	.860	....	....
Lawrence ...	Geo. Whitaker..	....	13.00	1.20	....	83.20	64.71	none	trace	2.00	none	trace	.064	....	....
Lawrence ...	From Shoals Furnace Co............................	....	13.00	.90	....	84.89	66.02	none	trace	1.00	none	....	.0449	....	....
Crawford.....	C. C. Taylor, near Marengo......................	....	33.00	6.10	5.10	33.92	30.05	3.95	2.00	6.80	7.30	.104	.221	....	....
....	Caldwell & Co., near Elizabeth, Ky..........	....	5.50	29.00	....	64.00	49.78	.70	.618	8.00	....	trace	.102	....	....
Warren	Cedar Bluff, No. 1......................................	....	....	10.10	....	47.86	37.22	.718	2.49	3.33	.218	....	....	....	35.282
Warren	Cedar Bluff, No. 2......................................	....	....	11.70	....	48.08	37.40	.857	1.89	4.48	.232	....	....	....	32.785
....	St. Bernard, Ky., (Black Band ?)...............	....	12.10	15.40	....	31.89	24.80	2.99	1.38	32.50	2.64	1.10	....	....	....
....	Red Mountain, Tenn.................................	....	....	23.20	....	66.00	51.33	trace	6.00	3.20	1.60	....	....	....	....
Sullivan......	Ferruginous Sand Stone, near Sullivan......	....	....	53.00	....	34.28	26.66	....	4.52	....	....	....	....	....	8.20
Posey	Pottery, from "Bone Bank."......................	1.00	23.60	36.00	....	5.50	....	....	5.00	25.50	3.20	.20	....	....	....

ANALYSES OF LIMESTONE AND HYDRAULIC CEMENT ROCKS.

County.	Name of Locality or Owner.	Moisture at 212°.	Insoluble Silicates.	Oxide of Iron.	Alumina.	Carb. of Lime.	Carb. of Magnesia.	Organic Matter, Alkalies, &c.	Sulphuric Acid.	Carb. of Iron.
Wabash	Davis Farm, near Somerset	1.00	30.60	....	16.72	25.60	12.713	10.887	....	2.48
Wabash	Helm Cr., near Wabash	2.00	34.20	....	18.76	28.00	3.117	12.681	....	1.242
Wabash	Chapelle, Cr., near LaGros	1.80	35.60	....	17.86	26.00	2.420	12.180	....	4.140
Clarke	Beach's Mill, Clarksville	0.50	19.60	....	14.57	37.00	2.631	20.862	....	4.634
Clarke	W. F. Beach & Co., Falls of the Ohio, middle	1.00	14.00	....	10.80	38.00	4.708	29.835	....	1.657
Clarke	W. F. Beach & Co., Falls of the Ohio, bottom	1.30	15.40	....	19.60	37.00	2.332	23.540	....	.828
Clarke	W. F. Beach & Co., Falls of the Ohio, top	0.50	15.50	....	3.50	53.80	11.348	14.873	.48	....
Cass	Near Logansport, Limestone	0.80	2.20	1.50	5.30	79.60	1.900	9.400	....	....
Miami	Wallack's Mill, near Peru, Limestone	1.20	6.40	....	14.343	45.00	23.610	7.790	....	1.657

New Providence,
Clarke Co., Ind., Dec. 1873.

Prof. E. T. Cox,

State Geologist of Indiana:

Sir—Agreeable to your letter of March 14, 1873, instructing me to make a Geological Survey of Clarke and Floyd Counties; to make examinations and note localities, and collect specimens of all minerals that are likely to be of commercial value; and obtain information on the manufactures and agricultural resources of the counties named, I submit the following report:

Very Respectfully, your obedient servant,

WM. W. BORDEN.

REPORT

OF A

GEOLOGICAL SURVEY

OF

CLARKE AND FLOYD COUNTIES,

INDIANA.

BY WM. W. BORDEN.

HISTORY.

The County of Clarke was laid off in the year 1801, at which time the whole number of its inhabitants did not exceed four thousand. The number of voters, who consisted only of freeholders numbered about three hundred and fifty. Until the purchase made by Governor Harrison of the Indians, the grant made by the State of Virginia to Gen. George R. Clarke and other officers and soldiers of the Illinois regiment, consisting of one hundred and fifty thousand (150,000) acres, it was the only tract in the county which belonged to the citizens of the United States, the remainder was owned by the Indians. This county was called Clarke as a tribute of respect to Gen. G. R. Clarke to whom the acquisition of this territory to the United States may be ascribed. Jeffersonville, situated on

the northwest bank of the Ohio river, nearly opposite Louisville, and a little above the commencement of the "great falls," was laid out in the year 1802 and was the first seat of justice of Clarke county. A land office for the disposal of the United States lands, and a post office were established here. Two pilots were appointed by law to conduct boats over the falls. Jeffersonville has grown to be a flourishing city and there are but few, or no better situations on the Ohio. The banks of the river at Jeffersonville are very high, and the current of the river for several miles above washes the northwest shore, and the depth of water is sufficently great at any season of the year for boats or vessels of any burden, affording at all times an easy landing place and good harbor for boats descending the Ohio river.

BLOOMS EDDY.

This eddy is just below the first rapid. The early settlers availed themselves of this eddy as a landing place, and made portages from this landing to Jeffersonville, the distance not being more than half as great, on the Indiana as on the Kentucky side, and it was supposed that Jeffersonville would eventually become the principal landing place for boats having to unload above the falls. There is also noticed in this early history, that in the vicinity of Jeffersonville, about one mile to the northwest is a *Medicinal Spring*, supposed to be strongly impregnated with sulphur and iron. It was a place of considerable resort for invalids many years, and the waters were believed to be beneficial in fevers that prevailed in the west. This spring flows from the New Albany Black Slate, and was owned by Mr John Fischly.

The State Prison South is located at Jeffersonville, and also the United States depot, for United States Army supplies. The Ohio Falls Car Works of this city are among the largest in the West and are engaged in the manufacture of a large number of passenger and freight cars. Here

are also extensive ship yards where it is probable that more steamboats are annually built than at any other point on the river. Pork packing is also a business of very great importance to this city, and is extensively carried on.

Besides the above there a number of other manufactures which though less in extent, serve to add materially to the prosperity of this city, which is, as well as the neighboring city of New Albany, very favorably situated for the successful prosecution of all kinds of manufacturing industries.

GEOLOGY.

The counties of Clarke and Floyd are divided by a line extending from the point of union, of Clarke, Washington, Floyd and Harrison counties in a southeasterly direction, to its intersection with Silver Creek, and thence along this stream to its junction with the Ohio river.

They are bounded on the north by Jefferson and Scott counties, on the west by Washington and Harrison, and on the south and east by the Ohio river.

The geological series represented within the above territory probably embraces a greater range of strata than is found in any other portion of the State. Beginning with the upper beds of the Cincinnati Group of the Lower Silurian, as seen in the northeastern part of Clarke County, it includes all the intermediate formations to the Pentremital limestone of the Sub-Carboniferous, at Greenville in the western portion of Floyd county.

The rock strata of this district were originally deposited horizontally, but at present are very much elevated in the northeastern border on the Ohio river.

These formations have the appearance of having been built up from the southwest, resting uniformily one upon the other, the lower always reaching farther east, than the formation immediately above, thus presenting to the geologist, on a grand scale, a wide field for investigation. The out-crop of so many different formations in this field is doubtless owing to the Cincinnati uplift, and to the effect of

erosion which has constantly been doing its work in wearing away strata.

As it is generally conceded by geologists that by fossils we may determine the equivalency of strata; as it were, the alphabet of the science; by them, therefore, I propose to identify the number and order of strata.

Water being the principal agent in the deposition of strata, the life of the ancient oceans has been buried in the sand, clay or lime which accumulated at the bottom. It is in this material therefore, subsequently changed to rock and elevated above the seas, that we now find their remains preserved in the condition of fossils.

Reasoning by analogy, from what is transpiring in the lakes, rivers and oceans of the present time, the conclusion is reached that countless myriads of organisms were ground to impalpable powder by the waves, and lost in the constitution of the rocks. Immense numbers of these remains although of frail structure are preserved intact, with their microscopic markings. Life abounded in the ancient Silurian sea which once covered the territory through which a portion of the Ohio river and some of its affluents now flow between corn covered hills. The coral reefs of these ancient oceans are now seen as limestone beds covered with the stems and heads, and long, gracefully waving and delicately fringed arms which belong to forms of a life, so old that the most exalted imagination of the poet and geologist, can have no adequate conception of the lapse of time since they were possessed of life.

THE CINCINNATI GROUP.

The lowest series of rocks exposed in the district composed of Clarke and Floyd counties, are seen in the northeastern part of the former county. The upper strata of the Cincinnati Group here outcrop at the mouth of Begg's Run on the Ohio river on tract No. 77, Illinois Grant, one and a half miles north of Fourteen Mile Creek. Begg's Run is fed by springs at the summit of the bluff some three

hundred feet above the Ohio river. The stream, by constant abrasion has worn a narrow and romantic channel through strata after strata to the river. In this locality the rock is a hard shaly blue limestone, carrying an abundance of characteristic fossils, which are exposed at extreme low water.

The following section was obtained immediately below the entrance of the stream into the river:

1.	Corniferous limestone....................	12 ft.
2.	Yellow rock—Magnesian limestone.....	20 ft.
3.	"Grandad" limestone used for building purposes..................................	4 ft.
4.	Gray Crystaline limestone, Niagara.....	14 ft.
5.	Crinoidal bed containing Caryocrinus, etc..	6 ft.
6.	Magnesian limestone.......................	20 ft.
7.	Blue and Yellow Clay shale...............	8 ft.
8.	Stratified magnesian limestone	75 ft.
9.	Blue shaly marlite..........................	100 ft.
10.	Dark blue shaly limestone, Cincinnati group...	20 ft.
		279 ft.
	Low water Ohio river........................	0 ft.

The upper part of this section from number six upward, correspond with the section at Utica, in Clarke county, where the rocks are quarried for lime and building purposes. The bluffs are here capped with corniferous limestone. The outcrop of the Cincinnati group here first exposed is on Camp creek; fourteen miles farther up the river, it is one hundred and eighty feet above the bed of Camp creek and two hundred and fifty feet above low water in the Ohio river. The elevation of the strata from that point to Marble Hill, six miles distant, and on the line of Jefferson county, will add about fifty feet more to this number. The Magnesian limestone which comprises the bluffs

on the river below the latter point, becomes the surface rock at many places on the bank of Camp creek and is in detached masses fifteen to twenty feet thick, and liable at any time, as their foundations weather away, to be precipitated into the valley below.

The general character of the Madison rocks, which belong to the Cincinnati group (in great force at Cincinnati), (Hudson River, so called, from being found on the Hudson River, N. Y.), as exposed on the bluffs of Camp Creek, are a thin stratified dark blue crystaline limestone, with intermediate layers of a lighter colored coarse grained limestone. At this point this formation carries an abundance of characteristic fossils—mollusca, corals, etc. The Marble Hill, marble stratum is also recognized here by its fossils, although in a disintegrating state.

The streams running into the Ohio at this point are tortuous in their course, and diminutive in size; their fountain heads being only two to three miles from the Ohio river, and they have worn their channel with difficulty through the rocks. The inclination of the strata is to the south-west, carrying the drainage a few miles west of the Ohio river into the head waters of Fourteen Mile creek. The country in the interior, a short distance from the river, is an alluvium flat which soon changes to fine rolling lands. Along the margin of the streams, and on the bluffs, the timber consists of Beech, (fagus), White oak, (Quercus alba), Buckeye, (Æsculus lutea), Poplar, (Populus canadensis), and Black Walnut, (Juglans nigra.) The dip of the strata in this region is to the southwest, at the rate of about twenty two feet to the mile. In places along the banks of the Ohio river, the rocks show in magnificient cliffs, some two or three hundred feet high. From the northeastern corner of the county the river flows along the line of strike in a southerly direction until it reaches a point near Utica, where it is abruptly deflected to the west, and runs nearly with the dip of the strata as far as New Albany where it is again deflected to the south.

At Marble Hill, on the line of Jefferson county, six miles from the mouth of Camp creek, the beds of the Cincinnati formation are well exposed. I obtained the following section in a ravine above the quarry, formerly worked by the Messrs. Dean:

1.	Covered space, slope of the hill.........	90 ft.
2.	Hard impure cavernous Sandstone, with surface weathered into holes.......	20 ft.
3.	Blue shale......	6 ft.
4.	Blueish limestone, magnesian............	20 ft.
5.	Deep blue marly limestone, with Cincinnati fossils................................	40 ft.
6.	Murchisonia shell marble, Dean's......	20 ft.
7.	Dark gray limestone.......................	40 ft.
8.	Fine grained marly limestone with green spots..................................	20 ft.
9.	Blue shaly limestone with Cincinnati fossils...	75 ft.
10.	Space covered with debris.................	12 ft.
		343 ft.

The hight of the ridge from low water is.. 373 ft.

For convenience of reference, I intoduce the following section of Dean's Quarry, as given by Dr. David D. Owen, formerly State Geologist, in a special report, with his remarks on the same:

1.	"Upper Cliff" composed chiefly of magnesian limestone, terminating at their base by the four foot bed, used in the construction of the Court House at Louisville, Kentucky..................	93 ft.
2.	Dark gray Madison water lime...........	13 ft.

3. Thin beds of blue limestone alternating with dark marlite	40 ft.
4. Dark gray marlite (hard pan)	10 ft.
5. Ditto, rather darker colored and more indurated	10 ft.
6. Shell marble of Deans Quarry, Marble Hill	20 ft.
7. Alternations of blue limestone and Marls	177 ft.
	363 ft.

"The greater part of the beds composing the Marble Hill quarry consist of an immense accumulation of spiral marine univalues, belonging to the fossil genus *murchisonia,* and chiefly to the species *bellicincta* intermixed with some *bicincta.* These shells are seldom perfect, more frequently broken,the fragments being cemented with calcspar, with occasionally a small percentage of protoxide of iron. An analysis of two specimens from the most important member of this section, the "*conchitic marble*" marked number six, was made by Dr. Owen and found to contain:

	No. 2a.		No. 2b.
Moisture	0.001	grammes	0.001
Lime	0.460		0.505
Magnesia	0.050		0.018
Protoxide of Iron	0.0328		0.015
Alumina	0.0052		0.010
Insoluble earthy matter	0.002		0.020
Carbonic Acid	0.434		0.426
Phosphoric Acid	0.006		0.005
Manganese	a trace		a trace
Loss and Alkalies	0.010		a trace
	1.000		1.000

The constituents appear to be combined in the rock as follows:

	No. 2a.	No. 2b.
Carbonate of Lime............	81.6	89.68
Carbonate of Magnesia.......	10.5	3.80
Carb.of the protoxide of Iron	5.28	2.30
Phosphate of Lime...........	0.90	0.85
Alumina..........................	0.52	1.00
Insoluble Earthy matter.....	0.20	2.00
Moisture..........................	0.10	0.10
Manganese......................	a trace	a trace
Loss and Alkalies..............	0.90	0.21
	100.00	100.00

The strata from which the above analysis was obtained, was extensively quarried by the Messrs. Dean in 1853. Many thousand yards of the stone, was cut by an extensive steam mill erected for the purpose, and distributed over the country. It entered into the construction of many public and private buildings, but proved on exposure to the weather to be unsuitable for the purpose, and has long ceased to be employed as a building material. The quarry and mill was abandoned more than fifteen years ago, but the ground in the neighborhood on the occasion of my visit was covered with large quantities of cut stone, in a weathered condition. The lines of light yellow in the interstices, and between the shells, being composed of a salt of iron which is oxidised on exposure, destroys the value of the stone. Time with its agents, moisture, atmosphere, freezing and thawing, are the best tests of the durability of building stone.

Although this stone has not proven to be durable for out-door work It is well adapted for inside ornamentation, and may be worked into mantels, table tops and other useful articles.

It takes a good polish, and is quite handsome, being filled with fossil spiral shells, which appear in fine contrast with ts dark ground

CLINTON GROUP OR EPOCH.

Immediately overlying the rocks of the Cincinnati formation, I have occasionally found a gray and yellow stratified sandstone, which I am inclined to refer, from its lithological characteristics, to the "Clinton Group" of the Ohio and New York geologists. It varies greatly, sometimes being hard at other times soft and easily worked. The thickness averages twenty feet.

It occurs at the summit of the ridge at Camp Creek; and continues to Marble Hill.

NIAGARA EPOCH.

The rocks belonging to this epoch, are so called from their appearance in great force at Niagara Falls. It is conspicuously displayed in Clarke county, along the line of the Ohio river, and occasionally occurs in the neighborhood of Charlestown, the county seat. The lowest outcrop of the Niagara is seen at extreme low water on the Falls of the Ohio, near the whirlpool on the Indiana side.

A characteristic fossil *Halysites escharoides*, or chain coral is here occasionally obtained. These rocks extend in a north-easterly direction to Utica on the Ohio river, seven miles above, where they are quarried for the manufacture of lime. The following section was obtained at Speed's quarry:

1. Corniferous limestone	12 ft.
2. Yellow rock, impure limestone	20 ft.
3. "Grandad," a building stone	4 ft.
4. Gray crystaline limestone, burned for lime	14 ft.
5. Upper bed Crinoidal limestone	2 ft.
6. Crinoidal bed containing Caryocrinus ornatus, etc, etc	4 ft.
7. Gray limestone	8 ft.
8. Magnesian limestone	5 ft.
	96 ft.

The "Yellow Rock," here forming the top of the Niagara appears to be a magnesian limestone and is well exposed in the quarry. At the head of Begg's Run it is weathered into large irregular shaped masses, presenting on the bluffs a columnar and castelated appearance which, in some instances, resemble the ruins of an ancient temple. One well poised block, six feet in diameter is termed "the head of the corner."

The limestone No. 2, 3 and 4, of the Utica quarry were used in the construction of the Ohio river bridge at Louisville. This bridge is one of the finest structures of the kind in the United States, and was built at a cost of over two millions of dollars.

We submit the following communication from the Louisville Bridge and Iron Company.

LOUISVILLE, KY., November 25, 1873.

WILLIAM W. BORDEN, ESQ.,

Assistant Geologist, Indiana:

DEAR SIR—Yours of 25th. inst is at hand. We made no detailed experiments of the crushing strength of the Utica stone which is used in the Ohio river Bridge, having been perfectly satisfied from its character, appearance, and chemical composition that there was no doubt of its being able to do all that would be required of it in this respect. We compared its ability to withstand the action of frost, with that of five or six other stones with which we were acquainted, by the method given in Millans Civil Engineering, page eleven, and found it perfectly satisfactory. We did not allow the ledges with blue seams to be used in the face work. Regretting that I am unable to give you more definate information I am,

Yours Respectfully,

I. W. VAUGLEAN, Vice President.

The gray crystaline limestone, number four of this section, contains immense numbers of corals, characteristic of the Niagara limestone of the New York geologists, among which the beautiful chain coral, Halysites escharoides, is quite conspicuous. I also collected specimens of *Eridophyllum rugosum, Favosites niagarensis, Cladopora multipora, C. reticulata,* and others of allied structure and beauty. It presents wherever exposed on the river a good face for quarrying. There is usually but little stripping required. The stone is easy of access, and convenient to the river for transportation; and is extensively used for building purposes. Some members of it are sufficiently firm and durable to answer the purpose of heavy masonry.

The lime burned from this bed and sold under the name of the Utica lime has acquired by long use a high reputation and where known is used in preference to all other brands.

J. Speed Esq., has erected at Utica two of Pages patent kilns, each producing one hundred and twenty barrels of lime per day. At Robinson's landing, a few miles above Utica, Mr. Jacob Robinson burns of the same stone ten thousand barrels per year. The fuel employed is wood and requires four cords to burn one kiln. The Utica Lime Co., use a mixture of wood and coal, and have two kilns, each producing ninety barrels of well burned lime per day. The Louisville Cement and Lime Co., and the Utica Lime Co., and Mr. J. Robinson burn one hundred and twenty five thousand barrels of lime per year employing in the business a large number of hands.

The upper bed in the above section is shaly and unstable for building purposes, yet when burned produces a good article of lime, which is highly esteemed for the purpose of purifying coal gas. Mr. Jonas Howard uses the same layer of stone in the manufacture of lime at the falls of the Ohio. The crinoidal bed of the Niagara is worked with the other members at the Utica quarry and in it are found many beautiful fossils of interest to the geologist. The remains of crinoids are abundant, yet perfect specimens are rare. Perhaps the most notable

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species is *Caryocrinus ornatus*, as this crinoid is here frequently obtained in a state of perfect preservation. The beds numbered seven and eight in the preceding section contain several species of Orthoceratites; and a number of corals with large cells resembling the genus Acervularia. The Niagara limestone is again seen a short distance above Utica at Charlestown landing. This is one of the oldest landings on the river. It was selected by the early settlers as being free from any danger, which might occur upon landing their arks near the "great falls" of which they had heard much but knew little. The out-crop at Charlestown landing is on the lands of Capt. S. C. Rucker and J. K. Sharp, Esq. Here are several extensive quarries, and the stone has been extensively worked for building purposes, and for making lime. At Sharp's quarry, below the landing, the following section was obtained:

1. Corniferous limestone....................	2–3 ft.
2. Yellow rock, magnesian, used for building	10–20 ft.
3. "Grandad" impure limestone.........	4 ft.
4. Gray crystaline limestone, used for lime	14 ft.
5. Gray limestone............................	8 ft.
6. Blue and yellow clay......................	5 ft.
7. Magnesian limestone.....................	18 ft.
8. Porous rock.................................	20 ft.
9. Soft magnesian limestone...............	25 ft.
10. Covered space to the river..............	53 ft.
	170 ft.

All the strata below No. 1 in the above column belong to the Niagara.

A section at Charlestown Landing would show a greater elevation of the strata on the river, and the elevation gradually increases as you go to the Mound Builder's Fort, one mile above, and to the mouth of Camp Creek, and Marble

Hill, in the edge of Jefferson county. There is an outcrop of the stratum marked No. 4, in the above section, on the south west side of Fourteen Mile Creek, near the summit of the hill, and on the road from Charlestown to the Mound Builders' Fort, in tract No. 76, Illinois grant. The fossils characteristic of this rock can here be collected without difficulty, as they are weathered out and lie scattered over the surface. Another exposure may be seen north-west of Charlestown, at "Nine Penny" branch, opposite "Tunnel Mill," on the road to New Washington. A section of the rocks show:

	1. Covered space above		20 ft.
	2. Crinoidal limestone, blue	Devonian	3 ft.
	3. Cement rock	Devonian	12 ft.
	4. Corniferous limestone	Devonian	22 ft.
Niagara.	5. Magnesian limestone with corals, and crinoidal stems		24 ft.
Niagara.	6. Dark gray crystaline limestone		22 ft.
Niagara.	7. Light drab magnesian limestone, weathering into irregular shaped holes		20 ft.
Niagara.	8. Blue and yellow clay		6 ft. 6 in.
Niagara.	9. Pinkish and gray magnesian limestone		6 ft. 6 in.
Niagara.	10. Stratified "marble," with green and blue spots		4–6 ft.
Niagara.	11. Hard, shaly magnesian limestone		10 ft.
	Branch		0
			151

The bed of Fourteen Mile creek, near this point, follows the base of the bluffs in the shape of a horse shoe. Samuel Works, the first proprietor of the mill, who located here over forty years ago, drove a four by six foot tunnel 315 feet in length through the narrow part of this ridge, and tapped the waters of the creek above. Motive power was thus obtained sufficient to drive three sets of burrs. This mill

in early days was the only grist mill in the county, and proved a great accommodation to the first settlers. It will stand as a monument of the perseverance and well-directed energy of its original owner. The mill is now owned and run by Wm. M. Green.

The corniferous limestone, immediately overlying the beds of the Niagara formation, constitutes, in the south-western part of Clarke county, the Falls of the Ohio. The beds have here a thickness of twenty-two feet, and extend across the river in a southerly direction, forming a series of rapids, on a direct line, of one mile and a half. The following notes are from the office of Major General Godfrey Weitzel, United States engineer in charge of the improvements of Louisville Canal. They were furnished by Phil. I. Schopp, Assistant Engineer. The distance from the upper dam to head of Portland wharf, taken in a direct line, is seventeen thousand feet. Length of Canal around the Falls is nearly two miles. Lift of locks in the Canal, twenty-two feet. Greatest depth of water at the head of the Falls is at the Kentucky shore, where it is thirty feet. The length of the Falls proper is two and one-quarter miles, and the fall in this distance is twenty-six and one quarter feet. Sand Island is at the foot of the Falls, opposite the mouth of Silver Creek. Above this is Rock Island. Then Goose Island, the largest of all, and Corn Island, now almost washed away. Opposite Jeffersonville is Willow Island, or Tow-head.

The length of the great railroad bridge which crosses the Ohio at the Falls is, from tower to tower, one mile.

The main body of the water at the Falls passes through the Indian chute on the Indiana side, and has a descent from twenty-six to twenty-eight feet. The river here flows over the outcroping edges of the strata and along the dip, which is almost west. These strata belong to the Corniferous and Niagara series. A section of the rocks at the Whirlpool exhibits the following:

1 Soil and clay.			
2. Spirifer gregaria bed	3 ft.	Corniferous. 22 ft.	
3. Crinoidal bed, nucleocrinus	3 ft.		
4. Gray limestone full of corals	4 ft.		
5. Black coral bed	12 ft.		
6. Gray crystaline limestone with Halysites escharoides	3 ft.	Niagara.	
	25 ft.		

The corniferous limestone in New York contains disseminated masses of hornstone, or impure flint, and hence the name corniferous from the latin *cornu*, a horn. The general color of this limestone here, as in New York, is a dark gray, but disseminated between the layers more or less bitumen is found, which gives to the surface in such places a darker appearance; hence, called by the quarry-men, black rock.

The locality of the Falls has long been known as the collectors Paradise. The rocks are the coral reefs of the Paleozoic ocean and they contain myriads of fossil forms which exhibit the exquisite workmanship of the Creator. The corals are in the greatest profusion, many being of an immense size, and delicate texture. The species are numerous. I obtained specimens of Favosites turbinatum, F. Troostii, F. fibrosa, F. maximus, F. Goldfussi, Cyathophyllum corniculum, C. Halli C rugosum, Amplexus Yandelli, Zaphrentes gigantea, Z. Rafinesquii, with many others.

Crinoids are rare, although the lamented Maj. Sidney S. Lyon after a search of twenty years at the Falls, accumulated a magnificient collection, which are of great interest to the scientific world.

The vast water power of the Falls should be utilized, and perhaps the day is not far distant when this power will be brought into requisition.

Messrs. Smith & Milton have a large merchant mill on the Indiana shore, below the Great Railroad Bridge—

driven by a turbine wheel. This is the largest mill about the Falls and is capable of grinding five hundred barrels of flour per day, and with the recent additions of building and machinery will have a capacity to manufacture eight hundred barrels per day of the best merchantable flour in the country.

The dip of the corniferous limestone being about twenty one feet to the mile, it disappears beneath the Hydraulic limestone at Beaches mill below the Falls. At Fourteen Mile Creek, twelve to fifteen miles above the falls it attains an elevation of two hundred and fifty feet, and caps the bluffs almost the entire length of the creek, affording a fine field for the amateur collector of fossils, and a good stone for the manufacture of lime, and the building of fences.

In the neighborhood of Charlestown, it is well exposed on the head waters of Pleasant Run, but disappears one mile below, in the bed of the stream where it is replaced by the Niagara. At Skaws mill, and the Black Diamond Cement mill at Silver Creek it is seen beneath the Hydraulic limestone. On the Sinking Fork of that stream it outcrops in various places.

I have repeatedly found this formation to contain small caves; some of them one half to one mile and a half in length; with an abundance of stalactites, and some evidence of cave life. I have no doubt if the floors of these caves were dug into, that the remains of extinct animals might be obtained, with perhaps relics of the "mound builders."

The most important rock, in an economical point of view, in the district composed of Floyd and Clarke counties is:

THE HYDRAULIC LIMESTONE.

The lithological, stratigraphical and palæontological, characteristics of this stone should be well understood by the inhabitants of the latter counties, where its outcrop may be seen in the banks of almost every stream. Its horizon is immediately above the corniferous limestone and below a forty two, to forty eight inch bed of crinoidal limestone which is over-laid, by the New Albany Black Slate. It requently occurs as the surface rock.

The color is usually a light drab, but sometimes it is of a much darker shade. The top layers of the Hydraulic stone is marked at various points by a dendritic crystalization of magnesia or lime. The upper beds contain cherty or hornstone concretions, with spicula of sponges and desmids.

The characteristic fossils of the Hydraulic or cement limestone are, Atrypa reticularis, Spirifer Owenii, S. euritines, S. barucosa, Hydrophyllum orbignyi. The stone is without cleavage and breaks with a conchoidal fracture. The average thickness of the strata is about twelve feet, and the bed is divided according to its hydraulic properties into *quick*, *medium* and *slow* setting. The *quick* setting variety is well marked in J. Speed's quarry on Silver Creek by a seven foot stratum, which diminishes in the time required to set, towards the bottom. The *medium* stone is from two to three feet thick and imperfectly parted from the *slow* setting stone, forming the lower part of the quarry. The lines of demarcation between the separate beds, although well marked, in some cases, are rather assumed lines of division.

On the lines where the Corniferous or Niagara are the surface rocks, the cement is wanting, that is, it has been worn away by erosion. The beds follow the line of Silver Creek from the Falls to the junction of the west fork, bearing east on the line of Pleasant Run, thence west of Charlestown with a more easterly belt following the Vernon Branch of the O. & M. R. R., as at Watson, and terminating northeast of Charlestown on A. Barnett's land, but appearing again at a few points north of Fourteen Mile Creek on the same line, as at J. McMillan's. The most western belt follows the line of Sinking Fork, cropping out on that stream, and to the west of it, as at J. Davis' Tract 169, Illinois Grant. West of this it disappears below the New Albany Black Slate. The most workable beds are on Tract No. 169, and No. 150, lands of Dr. Taggart; No. 132, lands of Collins McCoy deceased; and cement mill tract No. 130, Illinois Grant; and on Pleasant Run, and a narrow belt east of Charlestown, thence to the Falls. The cement rock

appears on the head waters of Fourteen Mile Creek, and disappears beneath the New Albany Black Slate two miles north of G. W. Mathews', Tract No. 152, Illinois Grant. Also, at A. M. Tucker's, Tract No. 153, Illinois Grant. The cement reaches far in the direction of Wm. Kirkpatrick's, formerly the residence of Ex-Governor Jennings.

I have traced the outcrop of this formation on fifty sections of the Illinois Grant, each containing five hundred acres, making twenty-five thousand acres of exposed workable beds. This estimate does not include twenty thousand acres more which may be reached by means of shafts and tunnels. There is but a small portion of the county in which the hydraulic limestone may not be found. Indeed, it is in quantity practically inexhaustable, and on account of its value for the manufacture of cement, will always be a source of profitable industry.

There are at the present time six firms in the county engaged in the manufacture of hydraulic cement.

The stone was first employed for this purpose at Verey's (now Beach's) mill, at Clarksville, on the Falls of the Ohio. The strata containing it, outcrops in the river bank beneath the mill, and the hydraulic stone is here fourteen feet six inches thick, as will be seen by the following section:

1. New Albany black slate			5 in.
2. Crinoidal limestone			4 ft. 2 in.
3. Dark, impure limestone, containing concretions of hornstone, with spicula of sponges	11 in.	Hydraulic limestone.	
4. Upper cement bed	4 ft. 1 in.		
5. Middle cement bed	6 ft.	14 ft. 6 in.	
6. Lower cement bed	3 ft. 6 in.		
Corniferous limestone			6 ft.
			25.1

The dividing line between the corniferous and hydraulic is not distinctly marked. The beds in the quarry are separated by lines of fracture, making occasional floors. The stone increases in hydraulic properties from below upwards, and is designated by the manufacturers as *slow*, *medium* and *quick* setting. It has no distinct lines of cleavage, and breaks with a conchoidal fracture. The extreme upper beds contain concretions of hornstone, with spicula of sponges. The overlying crinoidal bed is presistant and contains a good many fossils, which are difficult to obtain in good condition. It cleaves well, but is hard to work.

It is used in constructing the outer wall of the kilns in which the cement stone is burnt. The mill located here is one of the oldest engaged in the manufacture of cement, and has acquired a widespread reputation. Three kilns are employed in calcining the cement stone, preparatory to grinding. And the two sets of burrs at this mill are sufficient to grind fifty thousand barrels of cement per annum. The proprietor, Wm. F. Beach, Esq., employs a large number of men in quarrying, burning, grinding and shipping cement. On account of its being convenient to the river, boats may be loaded direct from the mill. A tunnel, with lateral branches, has recently been driven one hundred feet into the bed of hydraulic limestone, and the quality and thickness of the layers prove to be continuous.

The hydraulic limestone originally extended in one unbroken stratum across the river, but has been eroded, and now only a small portion of the original mass remains on Rock Island, near the center of the stream. Here there is a good exposure, and the rock is extensively quarried at Rock Island, which is below Goose Island. The cement rock may be traced at a low stage of water to the Kentucky shore. On the latter side of the river is the old Tarriscon Mill, originally built for grist purposes, but now employed by the Louisville Cement Company for grinding cement. About one mile above this is the new cement mill of D. Belknap & Co. The hydraulic limestone used at both of these mills is obtained from the bank of the river close by.

On the Indiana side of the river in Clarke county, six miles from Jeffersonville, on the line of the Jeffersonville, Madison and Indianapolis Railroad, on the bank of Silver Creek, is the cement mill of Hohn & Co. The hydraulic limestone outcrops in the bank of the creek and presents the same characteristics as at the Falls. This mill has four kilns and two run of stones. A short distance further down the creek near the railroad bridge, on Tract No. 48, Illinois Grant, is the Black Diamond Cement Mill of Dexter, Belknap & Co. This mill has sufficient capacity to manufacture seventy-five thousand barrels of cement per annum. It contains two sets of burrs and three kilns, and furnishes employment to thirty men. The fuel used is Pittsburg coal. The sales of the Company amount to thirty thousand barrels of cement per year, and is shipped in bulk, sacks and barrels, to all parts of the country. The hydraulic limestone used is obtained from the bank of Silver Creek beneath the mill. A section measured here exhibits:

1.	Alluvium..	4 ft.
2.	Dark col'd hydr'lic limestone, 6 to 8 ft.	13 ft.
3.	Hard, dark colored cement stone, 7 ft.	
4.	Corniferous limestone in the creek.........	6 ft.

The four foot bed of crinoidal limestone usually capping the hydraulic, being absent at this quarry, the only stripping required is the removal of the earth. The stone as a general thing is considerably harder and of a darker color than at other exposures, but the quality of the cement manufactured is equal to the best brands. About eight miles from Jeffersonville, near the J., M. & I Railroad, is D. Belknap & Co's Fall City Mill. The hydraulic limestone here attains a thickness of thirteen feet, with no overlying crinoidal limestone. The quarry is very extensive and furnishes all the limestone the mill is capable of grinding. The burrs are of the best quality and four and one half feet in diameter. The fuel employed in the four kilns used for calcining the stone is bituminous nut coal.

At Petersburg, near the crossing of the J., M. & I. Railroad over Muddy Fork of Silver Creek, and at Watson on the Vernon branch of the O. & M. Railroad, Messrs. J. Speed & Co., have two of the largest mills engaged in the manufacture of cement. The one at Petersburg has the capacity to produce one hundred thousand barrels per annum, and employs about sixty men. There are four sets of French burrs, four feet and one-half in diameter. The kilns are eight in number, built of the crinoidal limestone, which overlies the hydraulic, and lined with fire brick brought from Pomeroy, Ohio. They are each capable of producing from fifty to one hundred and twenty-five barrels of cement per day. During six days of last August, six kilns at this mill made two thousand three hundred and ninety-five barrels of cement. A section at the quarry adjoining showed:

1. Soil..4 to 6 ft.

The companies manufacturing cement on both sides of the Ohio river, in Indiana and Kentucky, have formed a copartnership under the name of the Union Cement Association, and have appointed Philip Speed, Esq., Agent, with an office at No. 113 Main street, Louisville. To this Association all the mills make returns and are apportioned a certain amount of cement to manufacture, so as not to glut the market. From data obtained at the Secretary's office, we tabulate the following statistics:

CEMENT MADE IN CLARKE COUNTY DURING THE YEAR 1[illegible].

LIST OF FIRMS.	BRANDS.	LOCALITY.	Annual capacity of Mills. Barr	Annual sales. Barrels.
W. F. Beach	Red Brand	Clarkesville, Clarke Co., Ind	50 000	22 350
W. S. Hohn & Co.	Silver Creek	Cementville, Clarke Co., Ind	75 000	35 245
Dexter, Belknap & Co.	Black Diamond	Cementville, Clarke Co., Ind		
D. Belknap & Co	Falls City	[illegible], Clarke Co., Ind	300 000	137 471
D. Belknap & Co	Crescent City	[illegible]ouisville, Kentucky		
J. Speed & Co.	Louisville Cement Co	Shippingsport, Kentucky		
J. Speed & Co.	Louisville Cement Co	Watson, Clarke Co., Ind	400 000	166 100
J. Speed & Co.	Louisville Cement Co	Petersburg, Clarke Co., Ind		
The month of December sales not included in the above				30 000
				391 166

The many uses to which cement is put in Europe, has impressed Prof. E. T. Cox, the Indiana Commissioner to Vienna, with its importance. There it is extensively used for laying pavements, in ornamenting buildings, making statuary, etc. He is of the opinion that the Indiana cement, commonly called Louisville cement, may be profitably used for similar purposes in this country. Occasionally in calcining the cement the rock is over-burned, making what is called a cinder; and it is here suggested that this "cinder," ground in connection with the other stone, will improve the quality of the cement. The manufacture of cement opens an interesting and wide field for investigation.

Various grades of cement are already manufactured, and there can be no doubt but new combinations of stone may be formed in Clarke county that will equal in value the Portland or Roman cement of Europe.

CRINOIDAL LIMESTONE.

This stone immediately overlies the hydraulic, and is seen at almost every locality where the latter outcrops, or is quarried for cement. It is a hard, gray, crystaline limestone, containing a great many fossils, principally crinoids, and also pentramites of the carboniferous type, intermediate between P florealis (Godenii) and P. pyriformis, (Say). The fossils of this limestone have been carefully studied and described by the late Major Sidney S. Lyon. Collectors in the neighborhood of the Falls have also enriched their cabinets with the fossils from this rock.

The collection of James Knapp, M. D., of Louisville, is undoubtedly the most complete in these fossils, and his collection of corals, made at the Falls, is the most extensive in the country.

A very nice collection of Falls fossils is also in the possession of Samuel L. S. Smith, M. D., of New Albany, to whom I am indebted for characteristic fossils and valuable information. The crinoidal limestone seldom attains a greater thickness than five feet. It is a poor stone for the manufacture of lime, but serves a useful purpose in the

erection of kilns for calcining cement, and is a reliable guide for denoting the position of the hydraulic.

The New Albany black slate is referred by the Ohio geologists to the Devonian, and the equivalent of the Genesee slate of New York. Prof. R. P. Whitfield, of Albany, N. Y., the able assistant of Prof. James Hall, remarks, that this slate has been referred to the Devonian on stratigraphical grounds alone. It is possible, therefore, that it is not correctly placed, as fossils are the only reliable means of determining its horizon. From this it may be inferred that the place of these shales is not satisfactorily settled.

The black slate is largely exposed at New Albany, and on that account I propose to designate it in this report as the New Albany black slate. It is usually of a jet black color, and occurs in thick beds, but after being exposed to the weather it exhibits a thin, laminated cleavage, and it assumes a pink, drab or mottled color. It contains sulphuret of iron in concretionary forms, and also in needle shaped crystals and cubes, familiarly known as "fools gold," or "sulphur balls."

Wells have been sunk at various points in this formation for mineral oil or petroleum, but without reaching it in any quantity. It contains a small per cent. of bitumen and burns quite readily when thrown into a hot fire, so long as the inflammable matter lasts. The bituminous character of the black slate has misled a great many persons, and caused them to expend large sums of money in searching in it for coal. The black slate is very presistant over a large extent of territory. It lies at the base of the range of hills known as the "knobs," and has been traced from the outcrop in Clarke and Floyd counties, Indiana, through Kentucky in a semi-circle to Portsmouth, Ohio. At one time it rested uniformly over Clarke and Floyd counties.

At the foot of the knobs near New Albany, according to the borings made by Dr. Clapp, the thickness of the black slate is one hundred and four feet, and from thence it may be traced in patches through the cement region to Rockford, in Jackson county, Indiana. It was struck at a depth of

twelve hundred feet in the artesian well at Terre Haute, and it outcrops on the Wabash river at Delphi, Carroll county, Indiana. But in many places it has been cut through and entirely removed by weathering, and glacial action, so as to leave exposed the underlying encrinital limestone. The valleys of deundation have a general direction—north-west and south-east. The Vernon branch of the O. & M. Railroad passes over the black slate south of Charlestown, and cuts it at several points below and above Lexington, in Scott county. On the west of Charlestown there is an outlier of the formation seventy to seventy-five feet in thickness. The Jeffersonville, Madison & Indianapolis Railroad passes over the black slate until it reaches White river at Rockford, Jackson Co., Ind. At Memphis and Henryville, on the line of this road, the black slate is largely exposed, and may be seen in the beds of the streams and extending some distance up the surrounding hill sides. Numerous, so-called, copperas banks are met with in this formation. One of these localities on Silver Creek, three miles from the mouth, is mentioned in the "Navigator's Guide," an old work published at Pittsburg in 1813, as furnishing "copperas as good as any brought to this country."

A noted copperas bank is found on Miller's Fork of Silver Creek, below Henryville.

The "black slate" has no economical value whatever at present. A few years ago it was thought it would make a good roofing material, ground and mixed with coal tar and spread on felt. A mill was erected at New Albany by Dr. Samuel Reid & Co. for the purpose of its manufacture, and large quantities of slate was ground and shipped to all parts of the country. It answered the purpose for which it was intended very well for a time, but ultimately it cracked by exposure to the weather, and was at last discarded as worthless. In my examination of the black slate I have invariably found a *ferruginous limestone* capping it, varying from ten to thirty inches in thickness. This limestone is very persistant and marks the top of the black slate over a large district in Indiana and Kentucky. It has a

fœtid odor when struck, and breaks with an uneven fracture. It is compact and durable and has been used in several sections for masonry, as at Memphis and Henryville, where it outcrops to a large extent. I have recently seen it four feet in thickness on the Knoxville Branch Railroad, in Kentucky, and it attains a thickness of thirty inches in Falling Run, below New Albany. At Blue Lick Post Office, in Clarke county, on the land of Thomas McDeitz, Jr., in the bed of a branch of Silver Creek, is the best exposure of this stone I have seen. So far I have not been able to detect any characteristic fossils in this stone beyond a few crinoidal stems. But I have no doubt the age of the black slate will be ultimately determined by the discovery of fossils in this formation, which from its position, is the equivalent of the goniatite limestone of Rockford, Indiana.

The knob measures of the Kentucky, or the siliceous group of the Tennessee geological reports, extend over the western part of the district composed of Clarke and Floyd counties, and constitute the broken range called "Silver Hills" by the first settlers. These hills, or knobs, extend from a point on the Ohio river below New Albany to the northern line of Clarke county. At the latter locality the range is called the Guinea Hills. The knobs, as their names imply, rise abruptly from the black slate to a hight of four or five hundred feet above the general level of the country. The margin of the outcrop of the knob formation is very irregular, especially on that portion west of Henryville, outliers being seen some distance from the main body. One of these, called the "Round Top" is near the fruit farm of J. F. Willey, Esq., another at Piney Point, south of Obadiah Nowland's, Buzzard Roost Point to the east, and also Crow's Nest Point to the west of Nowland's. The horse shoe range of knobs, entirely disconnected from the main body, are about one mile in extent, and on land owned by John Richardson. The prolongation of the knobs north-east of Henryville comprise several benches of table land. Where the base of the knobs cover a considerable area the top is usually flat, especially if the harder members of the formation represent

their summits. The rocks forming the knobs are arranged as follows:

NEW PROVIDENCE SHALE.

This shale lies at the base of the knobs and immediately above the ferruginous limestone referred to above, and has a thickness from eighty to one hundred and twenty feet. As you follow the line of the knobs to the north-west it becomes thinner, until at the Guinea Hills it is only fifty to sixty feet. It is a fine greenish colored marly shale, that pulverizes when dry without difficulty. It contains a great vartiey of fossils identical with those obtained at Button Mold knobs even miles south of Louisville, in Kentucky.

I have collected at several points from this shale: Spirifer Kentuckensis; two species of Chonetes, Orthis michelini, O. penelope, and an undetermined Orthis, a trilobite of the genus Phillipsia, and several species of chrinoids belonging to the genus Cyathocrinus, Platycrinus, Synbathocrinus, Actinocrinus, and Forbesiocrinus.

The corals are well represented by a number of Bryozoans. The shale is fissured in places and the cracks are usually filled with transparent sulphate of lime, or gympsum.

As many as six to ten bands of carbonate of iron have been found in this formation in a vertical space of about twenty feet. The lower band is usually on a level with the drainage of the country. These bands will average from four to six inches in thickness, and are separated from each other by from two to four feet of soft shale. They have a great persistency, and may be seen cropping out along the side of all the ravines. Attention was called to the importance of these ores in the second and third Reports on the Geology of Indiana. The following analysis of a portion of what appears to be the average of these ore bands found on the farm of John Stewart, Esq., north of Henryville, as taken from a paper published by the State Geologist, will serve to show their commercial value. The mass of the ore is of a bluish gray color, enclosed in a coating of red oxide

of iron one-eighth to one-fourth of an inch thick. This coating is very rich in iron, but was entirely excluded from the portion analyzed, so that the yield of the entire mass will be a little better than here reported. The net results are given in parts of 100:

Moisture dried at 212°	0.500
Insoluable silicates	16.400
Carbonate of iron	49.720
Peroxide of Iron	2.171
Manganese	2.500
Alumina	1.500
Carbonate of magnesia	14.000
Carbonate of lime	10.000
Sulphuric acid	0.686
Phosphoric acid	0.779
Loss and undetermined	1.744
Total	100.000

By roasting, this ore will lose thirty per cent. of volatile matter, which will increase the iron to thirty-five per cent., and the manganese to 3.571. A portion of the sulphuric acid would be eliminated, but the phosphorus will be increased to about .485, which is rather large. However, it is not improbable that a portion of the latter highly injurious ingredient may be taken out along with silica in the slag, and owing to the large per centum of manganese, if not a spiegeleisen, at least, a valuable Bessemer pig may be made from these ores. Owing to their leanness these ores should be roasted before being shipped to the furnaces.

Thomas Montgomery has on his land, Tract No. 274, Illinois Grant, three and a half miles from Henryville, a good exposure of iron ore, as shown in the following section:

1. Greenish blue shale	2 ft.	0 in.
2. Band iron ore, with intermediate kidney ore	0 ft.	5 in.
3. Greenish blue shale	4 ft.	0 in.
4. Band iron ore	0 ft.	5 in.

5.	Greenish blue shale	4 ft.	6 in.
6.	Band iron ore	0 ft.	6 in.
7.	Greenish blue shale	3 ft.	0 in.
8.	Band iron ore with kidney ore	0 ft.	8 in.
9.	Greenish blue shale	2 ft.	0 in.
10.	Band iron ore	0 ft.	8 in.
11.	Greenish shale	1 ft.	6 in.
12.	Band iron ore with grains	0 ft.	5 in.
13.	Shales	3 ft.	0 in.
14.	Ferruginous limestone, with crinoidal stems	2 ft.	6 in.
15.	New Albany black slate	6 ft.	0 in.
		31 ft.	6 in.

The ore in this bank was examined forty years ago by an iron master from Pennsylvania—Janes Works. He pronounced it good, and made preparation to erect a furnace, but the project was finally abandoned.

The ore crops out in almost every ravine in this region—everywhere of the same general character, and contains about the same quantity of iron. Another deposit of iron ore of considerable extent is seen on the land of Allen Barnett, near Broom Hill, on the New Albany & Chicago Railroad. Some of this ore has rather a peculiar structure, and is made up entirely of an aggregation of coarse particles of hydrated brown oxide. It is what is usually denominated kidney ore, and is scattered profusely over the surface. The whole country at the base of the knobs, where the New Providence shale outcrops, is rich in iron ore. It accumulates in the ravines and valleys by the washing down of the formation which contained it, and is generally easy of access.

The Jeffersonville, Madison & Indianapolis, and the Louisville, New Albany and Chicago, and also the Vernon branch of the Ohio & Mississippi Railroad, are about ten miles apart in Clarke county, and they all pass through the district containing these ore seams, and afford a ready means of shipment to the blast furnaces now in operation in this

State. But I should like to see one or more furnaces built expressly to smelt this ore, and either of the following cities would prove a suitable location, viz: Jeffersonville, New Albany or Indianapolis; the question of cheap fuel being of chief importance in the selection of the locality.

It is probable that the New Providence shale, on account of its mineral constituents, and being highly fossileferous, will make a good fertilizer. I have instituted practical experiments to determine its value, and forwarded specimens to the State Geologist for analysis.

A great number of mineral springs flow from the fissures previously mentioned as occurring in this formation, the waters of which possess decided medicinal virtues. One of the most noted of these springs is situated on the land of Sampson King, Tract 234, Illinois Grant. The water has been analyzed by the State Geologist and found to contain the following:

Alumina and oxide of iron.........	2.001	grains.
Sulphate of lime.....................	71.806	grains.
Sulphate of magnesia..............	429.660	grains.
Chloride of Sodium..................	286.090	grains.
Sulphate of sodium and potash...	204.400	grains.
	993.957	

This mineral has a similar composition to that from which the celebrated Crab Orchard salts of Kentucky are manufactured, and its use has produced good results in certain diseases where a simple alterative or cathartic was required. It is in good demand, and has been shipped to the cities about the Falls, and to other parts of the State. Another spring, of equal medicinal properties, is on the farm of John Stewart, north of Henryville. Augustus Reid, in Munroe township; and Parady Payne, a short distance from Blue Lick Post Office, have springs, the waters of which also produce the same medicinal properties. Mr. Hosea, near by, and Esq. King, of Carr township, have mineral springs of imilar water. This medicinal water, as predicted by

Prof. E. T. Cox, has been found at New Providence by deepening the well at Mr. T. S. Carters' stave factory, and no doubt will be found over the entire region of the shale. The New Providence shale is well exposed below New Albany at the base of the knobs. In this locality, as well as along the Corydon Plank Road, it attains its full thickness. Trestle No. 6 of the Air-line Railroad, rests upon its summit, and Trestle No. 1 is at its base; and the thickness is here more than one hundred feet. About the usual quantity of kidney ore is found also in it at this locality, but the stratified ore does not occur here as it does on the extension of this horizon into Clarke county. This shale at the base of Caney Knob, below New Albany, is capped by a thin stratum of ferruginous sandstone, while in the northwestern part of Clarke county it is covered by a thin fossiliferous limestone, composed of an aggregation of crinoidal stems. Specimens of the stone, ground and polished, exhibit a fine variegated surface. Above this hard band of shale is a bluish, friable micaceous shale, which I recognize to be the *true* knob shale. It ranges in thickness from one hundred and twenty to one hundred and sixty feet, and extends half way or more up the sides of the knobs, and in many cases where they are conical, it forms the summit.

In other places it is frequently capped with massive sand stone, or beds of impure limestones, containing crinoidal stems. In these shales are found fossil worm tracks, fucoids and concretions of iron ore of large size, and often containing brachiopods.

The massive knob sandstone, where capping these shales, is from fifty to eighty feet thick, in beds of various thickness. The upper part is composed of ferruginous layers ten to fifteen inches thick, and contain ripple marks on the underside. It hardens on exposure. This stone is used about New Providence for door steps, and many other purposes. A section of the knobs at Jarus Fordyce's, Esq., on the Greenville road, exhibits the following succession, commencing at the top:

1. Hydraulic limestone of Floyd county, with fossils............	5 to 10 ft.
2. First knob limestone, with chert beds..............................	20 to 65 ft.
3. Ferruginous sandstone, used at New Providence.................	3 to 4 ft.
4. Massive sandstone with alternate layers of shale, containing spirifer, *syringothyrus textilis*	40 to 75 ft.
5. Knob shale........................	100 to 160 ft.
	314 ft.

The first limestone of the Knobs No. 2 of this section has a gray color, with crystaline structure, and contains in some parts concretions of chert. It has a thickness of twenty feet at this point, but thickens toward the southwest, and finally reaches sixty.five feet. This is the stone so extensively quarried near Mooresville, in Floyd county, for building purposes about New Albany.

I have obtained from some members of this formation, especially at the Bryozoa bed, on Daniel Coates' land, near the sand bank, *Productus tenuicostatus* P. *punctatus*, P. *vitatus*, and a great variety of spirifers, and terebratula, with numerous Bryozoans. The sandstone, No. 4, of the above section is highly fossiliferous and contains *Spirifer, Syringothyrus textilis, Orthis umbraculum, Streptorhyncus, Keokuk, Orthis Keokuk, Spirifer propinquus,* S. *cuspidatus, Hemiphronites crenistriata, Productus reticulatus,* and a *conularia.*

Immediately above this fossiliferous limestone are found a number of thin layers of bituminous shale, containing an occasional coal plant fossil. The impure limestone, capping these formations resembles the Devonian hydraulic limestone of the cement region. I have no doubt if properly tested it will be found to answer the same purpose of that stone. It underlies the white sand, which is mined for the Star Glass Works, of New Albany, Floyd county, Indiana, at

the top of the knobs, near the intersection of Washington, Clark, Floyd, and Harrison counties. From this point to Greenville, in the western part of Floyd county, the following section is exposed:

1. Soil, red ferruginous clay.........	22 ft.
2. Pentramital limestone with Archimedes.........................	15 to 25 ft.
3. Blue limestone with intercalated shales.............................	50 to 60 ft.
4. Carboniferous hydraulic limestone, with fossils.................	5 to 10 ft.
	117 ft.

The shales of this section are of a bluish color and may be seen in the ravines and banks of the water courses underlying the pentramital limestone.

The members composing the knob series do not retain the same character throughout the district. They are not as uniform in composition as the formations below them, and they vary greatly in thickness and color, and are thicker at the western than at the eastern outcrop. A section from Spurgeon Hill, near Harristown, Washington county, to low water mark of the Ohio river at New Albany, will show all the Knob formations with their minute divisions from the upper pentramital limestone to the black slate:

1. Red ferruginous clay.............	20 to 30 ft.
2. Light gray shaly limestone, with Bryozoa, Pentramites, etc........	5 ft.
3. First chert beds, with geodes containing quartz crystals........	3 ft.
4. Dark gray chrystaline limestone with pentramites and crinoids, and a mass of fossils in some parts..................................	25 ft.
5. Light drab, soft magnesian limestone (hydraulic)..................	6 to 8 ft.

6. Blue shaly crystaline limestone, with shades of brown, full of fragments of crinoids.....		15 ft.
7. Blue aluminous shale............		16 ft.
8. Massive sandstone, stratified in the upper part.....................		25 ft.
9. Blue shale..........................		14 ft.
10. First limestone top of the knobs	20 to	65 ft.
11. Knob grit stone, with thin slabs in the upper part.................		20 ft
12. Knob sandstone, with spirifer, *Syringathyris textilis*, and *Streptorhyncus keokuk* (Orthis)......		40 ft.
13. Knob shale, with concretions of iron stone......................	100 to	120 ft.
14. Crinoidal limestone, with fragments of crinoids.................		2 ft.
15. New Providence shale, with iron ore, and fossils in some parts		120 ft.
16. Ferruginous limestone, with crinoidal stems.....................		3 ft.
17 New Albany black slate.........		60 ft.

It usually contains several thin beds of fossiliferous limestone containing *lithostrotion mamillare* The pentremital limestone has a thickness of twenty-five to fifty feet, in the neighborhood of Greenville, where it outcrops near the summit of the hills.

This limestone contains many fossils, as *Pentramites, florealis*, *P. sulcatus*, *P. konickana*,and a species of *Archimides.* The soil immediately covering the limestone is a tough, tenacious clay, colored with the oxide of iron. The following section is seen at Greenville, Floyd county:

1. Soil and clay........................	4 to	10 ft.
2. Light drab fine grained limestone, St. Louis................................		60 ft.

3. Pentramital limestone	20 to 50 ft.
4. Shaly limestone with fossils	30 ft.
5. *Very dark* stratified limestone with fucoid impressions in the upper parts	15 to 50 ft.
6. Light colored stratified limestone, with fossils	25 ft.
7. Light drab shale with *Bryozoa* and shells, at Alexander Hedden's branch	20 ft.

Several good quarries are worked in this vicinity; one near the camp ground. It is owned by Joseph Fetz. The stone is No. 5 of the above section, and is in layers from fifteen to thirty-six inches thick. It is a good building stone, and is used for repairing stone roads. There are two other quarries of limestone on the summit of the hill near the toll gate on the turnpike. One of these is worked by Morris Morris, Esq., of Greenville, and the other is owned by Dr. R. Smith, of the same place. The stone of these quarries is the true St. Louis limestone.

On the old New Providence road to New Albany, south east of Scottsville, below Aken's mill, on Big Indian Creek, the following section is seen in Aken's hill:

1. Ochrequs clay	5 to 10 ft.
2. Stratified chert beds (well exposed in this region)	12 ft.
3. Layers of stratified sandstone, alternating with shale	200 ft.
4. Massive sandstone with concretions of iron, and *Syringathyrus textilis* in the upper part	50 ft.
Bed of Indian Creek	0 ft.

Near the top of the hill towards Mooresville, beds of from ten to twelve feet of very soft, bright colored ochreous sandstone are exposed, portions of which is a good mineral paint. Buck Creek, a branch of Indian Creek, at Mooresville, near

the summit of the knobs on the Vincennes pike, is elevated one hundred feet or more above New Albany. A section on the Vincennes pike, in the knobs east of Mooresville, is as follows:

1.	Ochreous clay	4 to 6 ft.
2.	Stratified sandstone with flag stone	12 ft.
3.	Dark, crystaline limestone, gray with shades of brown, containing a mass of crinoidal stems and other fossils; used for building stone, curbing, etc.	4 to 8 ft.
4.	Massive knob sand stone (equivalent of Ohio Waverly S. S.) alternating with beds of indurated slaty clay	225 ft.
5.	Knob shale (greenish marly)	102 ft.
6.	New Providence shale, containing large masses of argillaceous iron ore, and carbonate of iron	126 ft.
7.	Greenish limestone band, top of New Albany black slate at Falling Run	2 to 3 ft.

The elevation of the country where this section is taken corresponds with that of the survey of the Vincennes turnpike made by Mr. Owen P. Owen. Through the kindness of Wm. F. Reid, assistant engineer on the New Albany and St. Louis Air Line Railroad, I obtained the following elevations:

The Corydon Plank Road, at the point where it is immediately above the eastern portal of the Railroad Tunnel, is four hundred and fifty seven feet above the mitre sill at the Louisville and Portland Canal. The elevation of the summit on which Edwardsville stands, at the point where the tunnel line crosses, is five hundred and seventy one feet, which is the highest point on the knobs, and is distant from State street, New Albany, five and one half miles. The

elevation of the head waters of Little Indian Creek, at a point near the western portal of the tunnel, is four hundred and twenty-nine feet. All the elevations about the Falls are taken from the same base line, viz: the mitre sill at the Louisville and Portland Canal. A section at Edwardsville, on the Corydon Plank Road, is as follows:

1. Covered space above		40 ft.
2. Gray limestone, used for making roads and paving streets, contains *Forbesiocrinus Worthenii*		30 ft.
3. Imperfect stratified crystaline gray limestone, with shades of brown, containing fossils		25 ft.
4. Massive knob sandstone with nodules of iron stone		125 ft.
5. Stratified sandstone and shale		220 ft.
6. New Providence shale and iron stone		126 ft.
7. Greenish limestone	2 to	3 ft.
The thickness of the New Albany black slate, at New Albany, from data derived from borings made by Dr. Clapp, is		104 ft.

I have enumerated in the foregoing remarks, the lithological, stratigraphical and paleontological characteristics of the rocks included in the district composed of the counties of Clarke and Floyd: comprising formations from the Lower Silurian to the Sub-Carboniferous. A section from the western line of Floyd county, to the eastern part of Clarke county on the Ohio river, will show these formations well developed, in the following order:

1. Soil and Clay ....20 to 40 ft.
2. Knob limestone—Keokuk Group.........80 ft.
3. Knob Sandstone, } Kinderhook Group..344 ft.
4. Knob Shale....... }
5. New Albany black slate } (?)
6. Crinoidal limestone..... } Hamilton Group...140 ft.
7. Hydraulic limestone.... }
8. Corniferous limestone —Upper Helderburg Group............................... 22 ft.
9. Utica limestone—Niagara Group......... 52 ft.
10. Magnesian limestone—Clinton Group... 30 ft.
11. Madison limestone.—Cincinnati Group.207 ft.

The minute divisions of the groups, in the above section are not always accurately defined, and are not everywhere present. They thin out, in some localities, to a knife-edge. Especially is the latter the case in the neighborhood of the Falls, where the characteristic fossils of the Niagara, Corniferous and Hamilton formations may be obtained within a verticle space of a few feet.

That the underlying, or outcropping rocks, in a very great measure, determine the nature of the soil, is plainly seen in Floyd and Clarke counties, where there are extensive outcrops of so many different formations, and each giving rise to a characteristic soil. In the northeastern part of the county of Clark are the rich but narrow bottoms of Camp Creek, leading to the large and very fertile "Bethlehem Bottom" on the Ohio river. These soils were enriched in ages past, and are destined to be for all time to come by the weathering of the fossil coral and shell beds of the Cincinnati Group, which rocks in this region are from one hundred to two hundred feet thick, and capped by magnesian limestone beds one hundred feet thick. These lands will ever remain productive, as they are continually enriched by the disintegration of the rocks above. The soil is a dark loam, partaking of the shade of the limestones. Camp Creek and Fourteen Mile creek are noted localities for Buckeye trees, many of which measure from three to four

feet in diameter, and attain a hight of fifty feet or more to the first limbs.

The summits of the river hills are from three hundred to three hundred and fifty feet above the streams. These hills are considered among the best fruit lands of the west. The fact is accounted for by some on the theory that the atmosphere is here tempered by fogs, and the radiation of heat from the river. It is known that a tub of water placed in a cellar, will maintain therein an evener temperature of the atmosphere. Water contains 140° of latent heat, which is required to retain the fluid in a liquid state, and this heat must be given off before the freezing point is reached. The 140° of heat is distributed by radiation to the atmosphere, and maintains an even temperature. Should the water be frozen, the heat of liquifaction in the water below the ice is a constant supply of caloric, influincing the ice to melt, or escaping in the form of vapors, called fogs, which rise to the summit of the hills, laden with heat, to descend as rain or snow after parting with its cloric by radiation. An additional explanation of the cause of the freedom from frosts, and the fruitfulness of the high lands, including the knobs, is the well known fact that the warmer strata of atmosphere is at the summit of the hills, while the colder descends into the valleys.

A few miles back from the head waters of Camp Creek the lands are wet, the soil is light-colored clay that holds water. The growth of timber is beech (*Fagus ferruginea*) and white oak (*Quercus alba*). In the vicinity of New Washington, the soil is a light clay and sand, and has a better drainage than the lands last mentioned. The line of drift reaches but a few miles south of the road from New Washington to Knabbs' station, on the Vernon branch of the Ohio and Mississippi Railroad, at the line of Scott county. An occasional bowlder is seen as far south as the Charlestown and Henryville road. But an abundance of large bowlders are found in the ravines at the "Guinea Knobs," southwest of Knabbs, and six miles northeast of Henryville. The land about New Washington is well

adapted for growing grass and wheat, and in some localities excellent corn It was in this region I noticed the best average prospect of wheat in the county, seeding with the drill having been extensively adopted. This region is well timbered with white oak, (*Quercus alba*) beech (*Fagus ferruginea*) and in some localities most excellent poplar (*Populus angulata*). The latter timber is more abundant to the south where the land becomes rolling, and the limestones begin to show. From the mouth of Fourteen Mile Creek, reaching as far down the river as Utica, and the Sinking Fork of Silver Creek, the land is rolling, and especially on the river, very much broken. The predominating rocks are corniferous and cement limestones, the base of a limestone soil; the bluegrass region ot the county. Charlestown is situated immediately on the summit of the corniferous limestone, from which flows abundant, never-failing springs of cool water. The drainage of the country is excellent. A very interesting cave is found on Mr. Bentley's farm, east of Charlestown, and another cave on tract No. 116, Illinois Grant, designated "Thomas Crew's" cave by Prof. E. T. Cox, on his recent visit to that place. "In this cave several small eyeless crustacean and centipedes were caught; also crawfish, with eyes. We also captured a small red and a small black beetle. A number of fragments of small bones of quadrupeds were picked up, and it is believed that an interesting osteological collection might be made by digging up the bottom of the rooms. Eyeless fish have been found in this cave by Mr. Thomas Crew." The easy weathering limestones render the soil of this region not only well adapted to bluegrass but likewise better suited to a variety of crops than that of any other portion of the county. Some of the farms in the neighborhood of Charlestown have been under cultivation for over seventy years, and excepting fields, where rotation of crops have been disregarded, their productiveness has not been perceptibly impaired. This soil is also well adapted to clover, and in some localities, especially on the river, fruits of all kinds are

grown in great perfection. The scenery here is very attractive. It is varied by undulating uplands and hills, through which flow small streams to the Ohio river, which lies to the south. In the distance the silver gray line of the "Silver Hills" (knobs) is easily traced in an unbroken chain from New Albany to New Providence. The two boldest peaks at Bennetsville, known as the "Hay Stack knobs," stand prominent in the view. A few miles west of this, and skirting the New Providence valley, are several outlying peaks (knobs) known as the "Hound's Leap," "Borden's Pine Knob" and the "Huckleberry Knob." The scenery in the knob region, near the boundary of Floyd, Clarke and Scott counties is grand and beautiful. The principal range is elevated four or five hundred feet above the level of the valleys, and is broken into numerous peaks, or knobs.

The bold escarpments, at the head of the valleys, form magnificent look-outs, from which a birds-eye view of the surrounding landscape may be obtained in all its beauty. The scenery viewed from the "Knobs" west of New Albany, is grand, "giving a most magnificent view of New Albany, Louisville, Jeffersonville, the Falls of the Ohio, the great Ohio river bridge at the Falls, and the far distant hills that loom up in grandeur along Salt river, in Kentucky." The "Knobs" are a favorite resort for the citizens about the Falls, also for strangers visiting these cities, as the hills afford a good birds-eye view of the surroundings. The view from Flower's Gap and the Round Top, on the farm of Col. Fletcher Willey, and north in the direction of Henryville, is one of very great interest. From the summit of Round Top a view of the surrounding landscape may be obtained in all its variety, the high lands of Kentucky are again seen appearing like a cloud sinking behind the distant horizon. The Ohio is assuredly entitled to the name originally given to it by the French—"La Belle Riviere" and from points above noted is seen meandering like a silver stream through the valley to the southwest. The view gives a succession of hill and dale, woodland and

cultivated fields, streams and rocks, most magnificently blended in a panoramic picture of which the eye does not weary.

A part of the land in Utica Township has not only the wash of the corniferous and Niagara limestone of this region upon it, but is in good part a river terrace, composed of altered drift, sand and gravel, with numerous aboriginal kitchen heaps. In the gravel or altered drift of this region are found mastodon remains and recent wood at as great a depth as thirty feet, which seems to indicate the situation of an old river or lake bed. Some of these deposits belong to the Champlain epoch, and these ancient waters must have washed the high lands about Charlestown, as on several occasions in sinking wells in the court house yard and other elevated positions at that town, pine or cedar wood has been exhumed. Some years since Mr. McWilliams, Col. Fletcher Willey and J. Coons obtained in a sand bank on tract No. 55, Illinois grant, the skeleton of a mastodon, (*M. giganteus.*) A part of the bones were sent to the old Louisville museum, the remainder are in the possession of Mr. J. Coons, who proposes to forward them to the State cabinet. A tusk six feet in length, which was taken out at the time, crumbled to pieces soon after being exposed to the air. Mastodon remains have frequently been found in the bank of the river at New Albany, in the same geological position. Utica Township is a noted market garden locality, which supplies Louisville and the cities about the falls with a large quantity of garden products — melons, sweet potatoes, Irish potatoes, and a great variety of fruits. This soil is also favorable to the growth of corn and grass. Wheat does well, and ripens early.

On the lands immediately west of Jeffersonville the New Albany black slate cuts off the limestone. The soil is an ash-colored clay, except where mixed with decomposed slate, which gives to it a darker color and adds to its fertility. The drainage is imperfect on the flat land but good where it is rolling; with proper tillage this soil is very productive. Mr. Samuel Patterson, of Jeffersonville, has improved his

land by under drainage with tiles. The slate lands in Clarke county are disconnected, appearing on one farm and absent on the next, or even present and wanting on portions of the same farm. The slate lands, when in large bodies give rise to beech and white oak flats, and are inclined to be wet, and necessarily difficult to drain. West of tract 169, Illinois Grant, the New Albany black slate appears in great force and continues unbroken in the direction of Memphis, where the north branch of Silver Creek, as at Eben Combs' mill, cuts through it to the depth of eighty-five feet. The land in the region of Memphis is well timbered, and the bottom lands produce good crops of corn and grass. The high lands here are clay, and give a generous return for all the fertilizers which may be put on them.

South and west of Memphis is the Blue Lick region. These soils are derived for the most part from the formation designated as the New Providence shale. This is a soft, light colored arenaceous clay-stone, containing some sulphate and carbonate of lime and magnesia. It is well exposed at Thos. McDeitz's, and on tract No. 219, Illinois Grant, on Blue Lick branch, Cany Fork, Cane Run, at the base of the knobs, at Allen Taylor's Esq., the foot of Round Top, at Sampson King's and at Wm. Stone's. At many of these localities this shale is rich in fragments of crinoidal stems and fossil shells, and several species of very delicate Bryozoa. The thin sections of crinoidal stems are disks, with a hole in the center, and resemble button-molds. These fossils are found in great abundance on the surface where the shale has been cut through by small streams and such places are commonly called "*Button-mold Washes.*" This formation also follows the North Fork, and Miller's Fork of Silver Creek, north and west of Henryville. The best White Sulpher Spring, known in Clarke county, is near the North Fork of Silver Creek, on the land of J. A. Boyer, tract No. 241, Illinois Grant, one and a half miles east of Henryville. This village is situated forty feet below the summit of the New Albany black slate. The soil of this region, as far as the base of the knobs, is clay,

belonging to the altered drift and alluvium in the creek bottoms. In the bottoms of Silver Creek the soil is very productive. Persimmon trees abound on the clay lands, which is light colored in the valleys, but changes to deep ochre shades as you approach the knobs. The altered drift is here characterized by containing a number of thin markings of black sand, which are seen in the cuts after a washing rain.

The mineral water mentioned under the head of New Providence shale, issues from this shale at the base of the knobs. Almost all the water at this horizon is impregnated more or less with mineral salts, derived from the overlying New Proidence shale. Water, entirely free from medicinal proprieties, is the exception, and pure water for culinary purposes is difficult to obtain, and can only be had by sinking shallow wells in the sand and gravel along the water courses. A very good quality of this mineral water is found on the land of Mr. Parady Payne, west of Blue Lick Post Office, tract No. 266, Illinois Grant. Another medicinal spring, containing similar properties to that at Mr. Payne's, is found on Mr. Hosea's land, south of the springs in Monroe township. On the lands of Augustus Reid and Sampson King are to be found springs of the same mineral water, and on the lands of Wm. Stone and Washington P. Butts, in Carr township, also west of Henryville on the land of Mr. John Stewart. On tract No. 266 Illinois Grant, the New Providence shale is eroded to the depth of sixty to seventy feet, and is entirely wanting at various points three miles east.

THE NEW PROVIDENCE VALLEY.

This beautiful valley, at the base of the tall, cone-shaped knobs, which were called "silver hills" by the early pioneers, lies in graceful curves which extend from hill to hill. This valley is about eight miles long, and one to two miles wide. In this valley may be recognized two distinct deposits. The older layers belonging to the Champlain epoch, originally gave the valley an elevation twenty

to twenty-five feet above the present level. The more recent deposit is from the shifting of the streams, and washings from the hill sides. A section of the older deposits would be as follows.

From the surface:

1. Alluvium soil.
2. Ochreous beds of many colors.
3. Fine grained sand, suited for colored glass.
4. Coarse gravel and sand, with fragments of fossils and limestone.

The bed of Silver Creek in this valley was at one time on a higher level than at present, and has shifted its course and cut down the clays of the valley to its present position. The weathering of the knob shales and sandstones, has furnished pebbles which have been born down by the floods from the hills, and, filling the bed of the creek, has altered its course from time to time. The spurs at the foot of the knobs, called "points," indicate the former level of the valley, and the course of the lateral washings. The shifting of the creek has thus created a rich surface loam, enriched by the decaying leaves and other vegetable matter from the hill sides, with a deep sub-soil of gravel. This soil is well suited to the growth of all the staple farm products, and the growing crops are not materially affected by drought. Apples do well, and strawberries grow to great perfection, as well as all other small fruits. The water in the streams and shallow wells of the valley is noted for its softness. It does not decompose soap, and is as much used as rain water for laundry purposes.

The forest growth of the valley comprises, the Red Mulberry (*Morus rubra*); the White Mulberry (*Morus alba*); the Pawpaw (*Anona triloba*); the Persimmon (*Diospyros virginiana*); Sugar Maple (*Acer sacharinus*); Sugar Tree (*Acer nigrum*). Among the original growth of timber of the valley, Walnut (*Juglans nigra*), and Chestnut of the hills (*Castanea americana*), were very abundant, and the nutting time of the year was a real harvest season. But

on account of the waste of the timber the chestnut crop is now small. We hope the time is not far distant when the ruthless hand will not lay waste the noble forests as formerly. There are also found, Shell bark Hickory (*Carya alba C sulcata*); White and Blue Ash (*Fraxinus americana F quadrangulata*); Beech (*fagus ferruginea*); Prickly Ash (*Zanthoxylum americana*); Wild Cherry (*Prunus virginiana*); Elm (*Ulmus fulva*); Sassafras (*Sassafras officinale*); Sycamore (*Platanus occidentales*), and many other species.

The timber of the hills consists of Chestnut Oak (*Quercus monticola*); White Oak (*Quercus alba*); Red Oak (*Quercus rubra*); Black Oak (*Q tinctoria*); Post Oak (*Q obtusiloba*); Pine (*Pinus mitis*); Black Hickory (*Carya amara*); White Hickory (*C. alba*); Dogwood (*Cornus florida*); Poplar (*Populus grandidentata*); Water Maple (*Acer rubrum*); Gum (*Nyssa sylvatica*), and Sumach (*Rhus aromatic*).

FRUIT.

The line of the knobs, and river bluffs, are famed as the best fruit growing region of southern Indiana or the West, as shown by the success of the orchards situated on the elevated lands below New Albany, and from thence to Moorsville, Scottsville, New Providence, and as far north as Salem in Washington county, and the walnut ridge west of Salem. This includes the southern and western knobs. The northern range above Henryville, going towards Vienna in Scott county, and the river bluffs from Utica to Marble Hill in Jefferson county, are all favorably situated for fruit growing, especially peaches, for the tender buds are not liable to be injured by spring frosts which are confined to the valleys below, and seldom reach as high up the hillsides as the orchards.

Extensive orchards are planted on the hills above Henryville. Col. Fletcher Willey and Gabriel Poindexter, fruit growers, have large peach orchards, and have shipped great quantities of fruit to Indianapolis, Lafayette and other markets. And the business of peach growing is

becoming one of the most profitable branches of farming in this part of the State. The peach orchards of Col. Willey and Poindexter at "Chestnut Flats," have from 15,000 to 20,000 peach trees. Messrs. Dean and Davis on the Ohio river below Marble Hill, near Otto, Clarke county, have peach orchards which number over 100,000 trees. Immediately below New Albany, Edward Mann Esq., secretary of the New Albany Ohio Falls Iron Works, Charles W. Cottom Esq., Dr. P. T. Green, W. Fawcett, D. H. Cadwalader, have also large peach orchards. Owing to a good exposure afforded by the knobs, the peaches here grown have a fine color, and no doubt a better flavor than fruit grown in the valleys.

GLASS SAND.

Lying in very compact beds at the summit of the knobs, and near the intersection of Clarke, Floyd, Washington and Harrison counties, is a fine grained white sand used in the manufacture of plate glass, at New Albany, by Mr. W. C. DePauw & Co. This formation is of very great economical value, and is designed to play an important part, and to add materially to the wealth of the portion of the district under investigation. Its geological position is immediately above the sub-corboniferous hydraulic limestone, as already indicated in previous sections. I have traced these beds of sand in isolated patches, from a point south of Spurgeon Hill in Washington county, in a southeasterly direction, to the present workable beds. The width of the sand formation increases as the summit of the hills become broader and more level. I have no doubt the white sand on the Ohio river hills below New Albany, in Harrison county, is a part of the New Providence beds, and that this formation marks the shore line of an ancient beach which extended northeastwardly in the direction of the Ohio valley. The sand beds are very uniform in thickness and quality. The quarry of the Star Glass Works at the summit of the Knobs, three and a half

or four miles distant from New Providence, and 350 to 400 feet above the Louisville, New Albany & Chicago Railway, has been extensively worked.

Through the kindness of Mr. John McKinley, Superintendent, and Jonathan Miller, I have obtained the following section of the beds at this quarry:

1. Soil, stiff clay loam......................	2 to 4 feet.
2. Yellow sand, colored by the overlying clay..................................	1 to 2 feet.
3. White sand, used for glass manufacture.......	16 feet.
4. Fragments of chert, with Bryozoa......	6 in.
5. Hydraulic limestone, at bottom of the cut..................................	4 feet.

The surface of the ground above the quarry is heavily timbered with white oak. The stripping is continued until the third bed of the section is reached, where the sand is mined by blasting, in the same manner as pursued in quarrying hard rock. After being thus loosened it is easily removed with a shovel.

The sand used at the New Albany Star Plate Glass Works Co., Mr. W. C. DePauw, President, when required for the manufacture of plate glass, is washed in an oscillating trough to free it from a small amount of impurities. Ten or more men are employed in quarrying and washing the sand, and they can prepare it ready for shipping as fast as twenty-five wagons can haul it four miles to the station at New Providence. The larger quantity is shipped to the Star Glass Works at New Albany, but some shipments are made to Louisville and Cincinnati. A bushel of sand weighs one hundred pounds or more before washing, and ninety pounds afterwards. One dollar to one dollar and twenty-five cents is paid per ton for hauling to the railway, and the washing costs $1.25 per ton. Freight to New Albany, $8 per car load of ten tons. Total cost, $3.25 per ton, at the depot at New Albany, exclusive of royalty. Shipped to

New Albany, the current year, two hundred and fifty-two car loads. Also, several car loads to Louisville and Cincinnati.

Weight of sand per barrel, 330 pounds.

Washed and delivered on the railway at New Providence, in barrels, per barrel, $1.00.

Delivered in Louisville, per barrel, $1.40.

Number of barrels per car, 65.

An outcrop of the sand occurs on the land of Michael Brock; another on the land of R. G. Scott and Mr. Jonathan Miller, all in the same neighborhood.

The shipment of sand and cement in barrels has necessitated the establishment of numerous cooper shops through the counties comprised in this district. Some of these shops are operated by steam and are on a large scale, manufacturing an immense number of barrels yearly. Mr. T. S. Carter, at New Providence, cuts on an average 500,000 staves per annum, and manufactures about ten thousand barrels. Thomas Akins, on Turkey run, J. Heaston and John Combs, at Memphis, Mr. Brookbank, at Jeffersonville, J. H. Cruzen, on the line of Scott county, and a stave factory or two at Greenville, Floyd county, and various other factories for cutting staves and shops for making barrels, are turning out a great amount of work. It is estimated that 300,000 barrels per annum are made in this district, which, at 50 cents per barrel, yields a revenue of $150,000.

The clays of Floyd and Clarke counties furnish the very best material for making brick, many thousands of which are manufactured every year in the neighborhood of New Albany and Jeffersonville. I have no doubt if returns were at hand from all the yards a very large capital would be found employed in this business.

The following imperfect returns will serve to convey some idea of the extent of this branch of manufacture in the latter city:

Mr. James H. Keigwin & Co. manufactured, in 1873, 6,000,000; Mr. Jas. Burk, 2,000,000; A. J. Howard & Co., 2,000,000.

The material employed is a clean, tough alluvial clay, containing sufficient iron to give the bricks a fine red color. Formerly Louisville was largely supplied with brick from these yards. Another important branch of industry is the manufacture of salt glazed pottery, commonly called stone ware. An establishment of this kind at New Albany, owned by Mr. Keller, turns out an immense quantity of ware.

Mr. George Uncer, at Port Fulton, manufactured during the past year 1,800 gallons of crocks and jugs per week. The material used is an alluvial blue clay obtained from the low lands in the vicinity. The same clay is also used in the manufacture of drain tiles, a branch which is yet in its infancy in this section. James Burk, of Jeffersonville, made during the summer of 1873, 50,000 feet, for which he finds a ready sale in the neighborhood of his kilns. The lands of Clarke and Floyd counties are well watered by never failing springs and numerous small branches, that rise in the Knobs, and flow into the creeks which empty into the Ohio river. Though the creeks are numerous there are very few of a large size. The principal streams of Floyd county are Falling run, Middle creek, Knob creek, Big and Little Indian creek, and Buck creek.

The streams of Clarke county are Silver creek with its numerous branches, which flow across the country and forms a part of the boundary line between it and Floyd, before reaching the Ohio river. There are, also, Wolf run creek, Miller's fork, and Cany fork, and Cane run, and Blue lick, tributaries of the North fork of Silver creek. The Dry fork, and South fork, Persimmon run, Indian camp run, Turkey run, and Knob run, are tributaries of the West fork of Silver creek.

Fourteen Mile creek empties into the Ohio river fourteen miles above Louisville. Owen creek, and Camp creek are below Bethlehem. There are a number of small streams in various parts of Clarke county that it is not thought necessary to mention. At the mouth of Fourteen Mile creek on the Ohio river is a very large Mound Builder's Stone Fort.

As it was visited by Prof. E. T. Cox during the fall, he will give an account of it accompanied with a map.

The region in the vicinity of the Falls of the Ohio river contains a great many ancient Indian burial places. Almost every elevation of the low lands or peaks of the Knobs show some evidence of having been occupied by a pre-historic people. There are several large mounds which have attracted much attention on account of the relics found in their neighborhood. One ot these, located on the farm of Mr. W. T. Aydelotte, six miles below New Albany, is formed of an immense number of common river shells. It is situated in the river bottom, a short distance from the stream, and covers a large space. It is about fifteen or twenty feet high, and has an oval or elliptical form. Several years ago Mr. Aydelotte had occasion to build a new house, and located it upon this mound above high water mark. In excavating the cellar, the shells were met within a foot below the surface, and are continuous to the bottom of the cellar. A quantity of human bones, including fragments of a skull, with the bones of animals, and quite a number of bone implements, were exhumed by the laborers and are preserved in the museum of the New Albany Society of Natural History. Subsequently, several stone axes, manufactured of Syenite and granite were found by farther excavation and have been also added to the collection at New Albany. The river bank from Mr. W. T. Aydelotte's farm to New Albany affords a fine field for the collection of Indian relics. Arrow heads are common, and frequently immense stone axes weighing ten or fifteen pounds are washed out of the bank during a freshet. Near Galena there is a small mound, where arrow heads have been found. The most extensive field for pre-historic research is at Clarkesville below the Falls, where there is an ancient burial ground on the river bank. During high water, large masses of the bank are undermined and topple into the river exposing the skeletons, which lie about two feet below the surface. At this place I have frequently found human bones protruding from the bank. The skeletons are

enclosed by pieces of slate placed on edge. They are buried in a sitting posture and are covered with shells, and fragments of pottery. Stone pestles and stone axes, a few years ago, were quite common and in the course of an afternoon a good collector might find a large number; together with a variety of arrow heads and other relics. Of the pottery found, one piece probably represented an owl, and was evidently used for drinking purposes. There is an opening at the back of the head and in the beak. Fragments of pottery are occasionally found which have ears that probably served for the attachment of the bail. Some pieces are marked as if moulded in a plaited basket. Implements of bone, including fish hooks, have also been found by careful search. Several years ago a copper spear point was picked up by a fisherman but unfortunately it has been lost. The ground in the immediate vicinity is covered with fragments of boulders that appear to have been broken by the action of fire when used for heating water. Frequently, fragments of bone are met with that have been cracked for the marrow which they contained. This burial ground extends along the river bank for three quarters of a mile to William Beach's cement mill, at the foot of the Falls of the Ohio. During the past summer in excavating the foundation for a new building at this place a stone pestle and axe, and a long stone implement similar to a rolling pin and a large quantity of shells were thrown out. These fine specimens were presented to Professor E. T. Cox for tne State museum by Mr. W. F. Beach. The margin of the streams appear to have been the favorite camping ground of this wonderful race, and upon nearly every rise of ground in the neighborhood are found unique relics illustrating their habits and modes of living. The New Albany Society of Natural History, although a recent institution, has been energetic in collecting these specimens of the ancient arts, and they have the most complete acrhæological museum in the valley of the Ohio. This collection comprises a quantity of flint implements ranging from the rude arrow head point to the finely executed flesh scraper, and a

variety of stone axes and pestles of many shapes, and elaborate workmanship. The bone implements and needles of the collection comprise a variety of forms, while the display of pottery is also quite varied in design.

CLARKSVILLE.

A small village situated at the foot of the Falls, opposite Shippingsport, in Kentucky, was laid out as early as the year 1813, by order of the Virginia Legislature; and attached to the grant made to the officers and soldiers of the Illinois regiment; from which time, may be reckoned the first settlement of this county. Soon after its establishment it contained a number of inhabitants who were encouraged to settle, under promise of donations of lots by the trustees; and notwithstanding the iminent danger and great inconvenience to which they were subjected, some of them continued to reside there to the end of the Indian war, and in a great measure, contributed to the safety of the inhabitants of Kentucky. Copperas banks were observed by the early settlers, in the bank of Silver creek, about two miles from its mouth. These copperas banks are frequently met with on the banks of Silver creek and Miller's fork, resulting from the pyrites of iron in the black slate.

It gives me pleasure to acknowledge here, the assistance I have received at different times from citizens of the counties reported on, while engaged in the prosecution of the duties assigned to me.

I am especially indebted to Samuel L. S. Smith, M. D. formerly of New Albany, for assistance and information.

I am also under obligations for favors, to Col. Horace Scott, General Superintendant J. M. & I., R. R.; Hon. A. N. Crystie, Vice President of the O. & M. Ry; and Robert H. Campbell Esq., General Freight Agent of the latter road; E. S. Crosier, M. D., Louisville; James G. Caldwell Jr.; and Felix Lewis, of Jeffersonville; Wm. F. Beach Esq., of Clarksville; Maxwell Little; G. W. Smith City Engineer; John Sloan, M. D.; George Cannon, New

Albany; E. B. Gurnsey Esq.; Rev. John F. Willey; J. L. Carr; John Richardson; Judge A. Lovering; John Stewart; Augustus Reid; Allen Taylor; H. H. Ferguson, M. D.; and M. E. Wisner, M. D. of Henryville; Esquire Weir; Wm. Combs; Eben Combs; and others of Memphis. Also, Thomas McDeitz; Sampson King; and Parady Payne, of Blue Lick; W. Briton, M. D., New Washington; Geo. Briton, of Bethleham; Messrs. Argus Dean, Wm. Dean & Wm. Stacy, of Otto; also, James Beggs; A. J. Hay, M. D.; J. Robinson; Allen Barnett; D. S. Coons, County Treasurer; Chas. McCaw; J. Ingram, County Clerk; G. W. Mathews; J. K. Sharp; and Capt. S. C. Rucker, of Charlestown; Joseph Pierce; Jairus Fordyce; Daniel Coats; Michael Brock; A. Q. Standiford; J. D. Hurn; Wm. Stone; John McKinley; Charles Robertson, of New Providence; Capt. Marion Smith, and Mr. Morris Morris, of Greenville. And many other citizens of Clarke and Floyd Counties.

We are under obligations to Mr. C. W. Cottom, of New Albany, for the following notes:

HISTORY OF NEW ALBANY.

"New Albany is the county seat of Floyd county; was laid out in 1813, by Joel Abner and Nathaniel Scribner. The land was purchased by the Scribner brothers of John Paul, who entered it at the Government Land Office, in Vincennes. The lots were disposed of at public auction, on the first Tuesday and Wednesday of November, 1813, and there was a stipulation in the advertisement of the sale, that "one-fourth part each payment upon the lots sold, shall be paid into the hands of Trustees, (to be chosen by the purchasers), until such payments shall amount to five thousand dollars; the interest of which was to be applied to the use of schools in the town, forever." With this fund, the Scribner High School, of New Albany, was founded, and has flourished, up to the present time, through the period of fifty-nine years, and is now one among the most efficiently

managed and prosperous high schools in Indiana. The city is noted for the number and success of its manufactures. The Woolen and Cotton Mills Company, Mr. James Haines, President, and J. F. Gebhart, Superintendent, are doing a large business. The aggregate business in wool and woolen fabrics, and cotton and cotton fabrics, during the year 1873, reaches the sum of $1,034,000.

The most extensive glass works of the kind in the United States are located at New Albany. The works are organized under the name of the Star Glass Company. The Plate Glass Works have a capacity for the production of 1,000 feet per day of the finest quality of polished plates, 92 by 180 inches in size. I have been informed that the polishing department is to be largely increased during the coming season. These extensive works have a capital of over $550,000 employed in the manufacture of glass. Silver plated glass mirrors were first made in this city during the year 1872. There are, in New Albany, some of the most extensive foundries and machine shops in Indiana. The machine shops of the Louisville, New Albany and Chicago Rail Way. The shops of D. C. Hill & Co., and Johnson & Webster, have a large capital invested. There are also stove foundries, brass foundries, Tanneries, forge works, planing mill, by J. B. Friend, Flouring mills, by R. P. Main, J. F. Leyden & Co., and City Mill, by Peter Mann.

There are two immense rolling mills at New Albany, the Ohio Falls Rolling Mill, and the New Albany Rolling Mill, of J. Bragden & Co."

PROFESSOR E. T. COX:

State Geologist:

DEAR SIR:—Herewith I submit my report on the geology of Warren, Lawrence, Knox and Gibson counties, and a paper on the Tripoli beds of Dubois county.

Returning my thanks for your many courtesies, I remain

Yours truly,

JOHN COLLETT.

NEWPORT, IND., March, 1874.

GEOLOGY

OF

WARREN COUNTY.

BY JOHN COLLETT.

TOPOGRAPHICAL DESCRIPTION.

This county is located in the middle northwestern part of the State. It is bounded on the south by Vermillion, southeast by Fountain, east by Tippecanoe, north by Benton, and on the West by the boundary line between Indiana and Illinois, and contains 360 square miles. Several good mill streams, as Redwood, Rock, Kikapoo, Pine and Little Pine creeks, have their sources near the western or northwestern parts of the county, and flowing in a southeasterly direction, fall into the Wabash. These, with many smaller creeks, furnish an abundance of water. Springs frequently burst forth at the junction of the Boulder drift with the underlying rocks; while the drift itself is seamed with partings of quicksand, which, charged with underground streams at deep cuts, or pierced by wells, furnish an unfailing supply.

The topographical features of the county are agreeably varied. The western and northern parts, embracing

more than half of its area, present a broad stretch of Grand Prairie in a prairies' most favorable aspect. Its soil is deep, black, and produces, without manure, in unlimited succession, large crops of corn, oats and grasses. The surface is undulating or gently rolling, and offers ample facilities for drainage, without any "waste" land whatever; while from the tops of any of the slight knolls or prairie ridges, the eye is delighted with miles of corn fields, or leagues of blue grass pasture and meadow land, diversified with island groves or their partings of timber. Adjoining the prairie region to the south and east, is a wide belt of high, rolling or hilly land, that descends gently to the abrupt or precipitous bluffs, bounding the valleys which the Wabash, and the creeks which flow into it, have cut down through the underlying coal measures—through the conglomerate sand rock, and deep into the sub-carboniferous formation. The soil of this belt is mostly yellow clay, formed by decomposition of Silurian, Devonian, and sub-carboniferous lime rocks, imported by rivers anciently flowing at this level. It is rich in tree food, and was originally clothed with a dense forest of oak, hickory, ash, walnut, poplar, beech, maple, and other large trees. Beech and sugar tree predominating on the reddish clay soils, and oak trees on drift clays or sandy soils.

The bluffs along the Wabash river and the principal creeks are from 80 to 150 feet in height, and are of romantic boldness. The tops at several stations are crowned with pines and cedars, and the sides are generally curtained by living walls of conglomerate or sub-carboniferous sand rock.

The river and streams are belted by "bottoms" characteristically fertile. These were originally covered with a heavy growth of walnut, burr-oak, hackberry, maple, cottonwood, sycamore, buckeye, elm, spicewood and pawpaw. Cleared and improved, these bottoms produce satisfactory crops of corn, grasses and potatoes.

GEOLOGY.

Surface Geology.

The surface deposits of this county comprise two members of the *Quaternary* or most recent of the geological formations, viz: *Alluvium*, new, or ancient, and the *Boulder drift*.

The alluvial river bottoms owe their origin to causes now in action. They are formed of sedimentary sands and clays torn away and transported by streams at a stage of high water and thrown upon their flood plain by overflow. The soil is quite sandy, but largely intermixed with decayed leaves and other vegetable matter, it is in effect a rich, warm calcareous loam or garden mould.

At an elevation of from 60 to 90 feet, near the present channel of the river, are found wide areas of the *more ancient* alluvial formation; as the Mound Prairie, opposite Covington, and the "barrens" adjoining, the valley bottoms extending south from Williamsport, along the railway line to Rock creek and near the mouth of Redwood, and the bench of "barrens" south and west of Independence. The soil of this formation is generally a warm, black loam, but sometimes, as near and west of Independence, sand and colder clays predominate. It is underlaid by gravel, sand, or rounded fragments of sandstone, and from the wide range of the deposit extending miles on either side of the river, from the great depth and uniformity of the material, we may date back the age of these terraces to a period when they constituted the flood plains of the Wabash, then a mighty river, miles in width, which bore, in a broad channel vexed with numerous islands of conglomerate sand rock, the surplus waters of Lake Erie, to the sea. Still higher reaching up to the most elevated points in the country and full 200 feet above the present bed of the river, are found the *oldest alluvium*—terraces and banks of modified drift, gravel and sand, (as at Walnut Grove, towards the northwest corner of the county, township 23, range 9).

These signalize the infancy of the river, when an insignificant and currentless stream, with uncertain course, the Wabash, traversing all the region from 30 to 40 miles on either side—sometimes flowing around through Illinois—sought, by the line of least resistance, the easiest pathway to the mouth of the valley of the continent.

The *Boulder drift* next succeeds in age. This formation is well developed in the west and northern parts of the county and in fact underlies all the Grand Prairie district. It consists of tenacious gray and blue clays, obscurely laminated, and holding a very considerable proportion of worn and polished pebbles and boulders. Some of the latter are specimens of the Devonian and Silurian rocks in northern Indiana and Illinois, but a larger proportion are metamorphic or transition rocks from the neighborhood of Lake Superior, or from still more Arctic regions. The boulders and coarse gravel are scattered from near the top down to within 5 to 20 feet of the bottom of the drift; for these clays were in a soft and oozy condition, and the heavy masses of granite would naturally sink some distance in the pulpy mass. As a consequence, when boulders are found on the *surface*, we may safely conclude that erosive action had carried away the finer matrix, leaving bare the heavy rocks. These in return, by their number, are a measure of the amount of denudation. Partings of quicksand and thin layers of stony fragments from neighboring strata are found located at large intervals through this formation; showing that for short spaces during the drift period, the great ice bearing stream from the north was obstructed or overpowered by cross currents from the east or from the west, thus mingling with the northern drift, fragmentary materials from Indiana, Illinois and Iowa. Near the base of the drift, and resting on a broken and irregular floor of coal measure rocks, is generally found a bed of potter's clay, somewhat intermixed with quicksand and black muck. A marked bed of the latter was met in sinking the West Lebanon shaft. From the soil or peat here discovered, a large number of roots of trees, shrubs and plants of pre-

glacial age were found in situ, specimens of which are placed in the State Cabinet. The foregoing deposits may be arranged in the following:

General Sections of the Drift, etc.

Soil..	2	to	5	feet.
Alluvium, *recent*........................	5	to	12	feet.
Alluvium, *ancient terraces*.........	70	to	15	feet.
Boulder drift............................	50	to	175	feet.
Boulder clay and vegetable matter	10	to	5	feet.
			212	feet.

PALEOZOIC GEOLOGY.

The visible rocky formations of this county commence nearly at the middle of the coal measures (coal No. 7 of Illinois or M. of Indiana) and extend down to about the top of the knobstone shales of the sub-carboniferous period, and may be classified in the following divisions:

CARBONIFEROUS AGE.

Carboniferous Period.

(a) Coal measures.
(b) Conglomerate sand rock.

Sub-carboniferous Period.

(a) Chester sandstone.
(b) St. Louis and Keokuk beds.
(c) Knobstone shales.

These formations, gathered in detail from isolated stations in different parts of the county, may be grouped in connected section as follows:

CONNECTED SECTION OF WARREN COUNTY.

No.			
1.	QUATERNARY.	Soil	10 ft. 00 in. to 2 ft. 00 in.
2.		Recent alluvium	20 ft. 00 in. to 5 ft. 00 in.
3.		Ancient alluvial terraces	70 ft. 00 in. to 20 ft. 00 in.
4.		Lacustral alluvial terraces	10 ft. 00 in.
5.		Boulder drift	30 ft. 00 in. to 170 ft. 00 in.

[*Total Quaternary, 207 feet.*]

6.	CARBONIFEROUS.	Yellow flaggy sandstone, soft and micaceous	8 ft. 00 in. to 9 ft. 00 in.
7.		Hard ferruginous sandstone and iron stones	4 ft. 00 in. to 2 ft. 00 in.
8.		Black sheety slate	0 ft. 6 in. to 1 ft. 4 in.
9.		COAL, M, pyritous, caking	0 ft. 10 in. to 1 ft. 8 in.
10.		Fire clay, with stigmarial rootlets	2 ft. 2 in. to 3 ft. 4 in.
11.		Soap stone and silicious shale, changing to argillaceous sandstone	5 ft. 1 in. to 18 ft. 4 in.
12.		Fern bed, white soap stone	0 ft. 6 in. to 2 ft. 3 in.
13.		COAL L, averaging 2 ft. 9 in.	0 ft. 10 in. to 4 ft. 6 in.
14.		Fire clay, plastic	3 ft. 6 in. to 4 ft. 00 in.
15.		Clay shale and ferruginous sandstone	8 ft. 00 in. to 17 ft. 00 in.
16.		Black bit. limestone, or calcareous shale	2 ft. 6 in. to 4 ft. 6 in.
17.		Black sheety slate, with pyritous ores	0 ft. 10 in. to 8 ft. 2 in.
18.		COAL K, average 3 ft. 2 in.	2 ft. 00 in. to 3 ft. 8 in.
19.		Fire clay	3 ft. 1 in. to 3 ft. 6 in.
20.		Black clay shale, with bands and massive concretion of calcareous iron ore	30 ft. 00 in. to 8 ft. 00 in.
21.		Flaggy ferruginous sand stone, tracks of reptiles, sun cracks, and fucoids	12 ft. 00 in. to 8 ft. 00 in.
22.		Heavy bedded quartzose sandrock	8 ft. 00 in. to 14 ft. 00 in.
23.		COAL A	2 ft. 00 in. to 0 ft. 00 in.

[*Total Carboniferous, 113 feet 3 inches.*]

24.	CONGLOMERATE.	Laminated sand stone...............	8 ft. 00 in. to 20 ft. 00 in.
25.		Massive conglomerate yellow, red, white and striped with few pebbles........................	60 ft. 00 in. to 90 ft. 00 in.

[*Total Conglomerate, 110 feet.*]

26.	SUB-CARBONIFEROUS.	Dark aluminous and pyritous shale..................................	5 ft. 00 in. to 18 ft. 00 in.
27.		Laminated thin bedded sand stones, and grit stones, changing at north to silicious shales	10 ft. 00 in. to 24 ft. 00 in.
		Bands and nodules of clay iron ore, with coal plants and sub-carboniferous fossils......	1 ft. 00 in. to 2 ft. 06 in.
28.		Impure limestone with fossils.....	4 ft. 2 in. to 1 ft. 8 in.
29.		Red and green shales.................	3 ft. 6 in. to 2 ft. 00 in.
30.		Impure limestone.....................	1 ft. 8 in. to 0 ft. 00 in.
31.		Clay shale....................................	4 ft. 00 in. to 0 ft. 2 in.
32.		Yellow limestone, Keokuk and St. Louis..............................	1 ft. 2 in. to 0 ft. 00 in.
33.		Clay shales, with lean iron ore...	1 ft. 00 in. to 0 ft. 8 in.
34.		Shale, siliceous, weathering dark gray or blue, with bands of chert. No fossils..................	20 ft. 00 in. to 40 ft 00 in.
35.		Knobstone shales and sand stone to Wabash river..................	10 ft. 00 in. to 5 ft. 00 in.
		[*Total sub-carboniferous, 91 feet.*]	— —
			521 ft. 9 in.

The surface deposits have already been considered under the head of Recent Geology. As there stated, they cover the entire area of the county. If it were not for the erosion of river and creek valleys, the rocky formations of this county could not have been seen. This explains the apparent limitation of stone or coal outcrops to the neighborhood of streams and rivers, while in fact though deeply covered, they exist in other parts as well.

SUB-CARBONIFEROUS GROUP.

This system is known by the name of *Carboniferous* limestone, and by the English geologists as the Mountain

limestone. It will be seen that these names, although generally proper, are here a seeming misnomer, as the system is composed almost wholly of siliceous material. This siliceous character predominates as well in northern Illinois. Here life was not abundant in the shallow muddy seas of the sub-carboniferous period, yet sufficient to fully determine the geological position of the rocks.

Knobstone Beds.

Synonyms: Chemung, (Hall); Waverly, (Ohio); Kinderhook, (Illinois).

These beds No. 35 of General Section are largely developed in Southern Indiana at New Providence and at New Albany, where they were first studied by Dr. D. D. Owen. The name there applied of "knobstone group or beds," is peculiarly appropriate and taking precedence by priority, is retained. In this country they are slightly developed and without fossils as far as seen, and are identified from stratigraphic and lithological reasons alone. They consist of gray or dove colored shales and shaly sandstones, near low water mark in the Wabash, at and above Independence, and *below* the thin chert beds at that place, and Flint creek in Fountain county.

Keokuk and St. Louis Beds.

These beds, Nos. 28 to 34 inclusive, are found in the bottom of the Wabash river, a short distance below Williamsport. Thence rising to the north and east, they exhibit a thickness, on the river bank in front of town, of about 30 feet, at the summit of a sub-carboniferous ridge; beyond which the strata are depressed at the Warwick farm to within 20 feet of the river, thence eastwardly they continuously thicken to Independence and the east line of the county, where they show a depth of over 50 feet.

Toward their base, these rocks consist of gray, green, blue and buff shales and shaly sandstones, and are distin-

guished from the knobstones by the occurrence of plates of white chert, as at the foot and sides of the hills east and west of Independence. In the upper division intercalated among the shales are found beds of impure limestone from one to three feet thick, as at low water in front of Williamsport, at the Iron bridge and along the bluff north-east of town, and on Little Pine at Bestana Munson's.

The fossils generally belong to the Keokuk epoch, yet as some of them are equally characteristic of the St. Louis or a later epoch, I have classed the two beds together. These animal remains from different horizons, are promiscuously mingled. We may infer that their habitat was in some adjoining area of clear water; that for short periods the muddy flats which gave origin to the companion shales deposited their sediment and became clear; and that at such periods, these animals introduced themselves, to perish at the next suffusion of impure water. The following list found at Williamsport and Little Pine Creek, exhibits the life of this epoch.

Archimedes Wortheni, (spiral axes and lace-like flanges)., *Aulopora*, *Crinoid* stems, plates and spines; stems and plates of *Pentremites* broken or separated, *Productus punctatus*, *P.* (*cora*) *tenui-striatus*, *P. semi-reticulatus*. *P. muricatus*, *P. longispinus*, (with spines 2½ inches long), *Spirifer Keokuk*, S. *textus*, *Athyris ambigua*, *Rhynchonella*, *Bellerophon*, *Nautilus*, *Chonetes* and *Hemipronites crenistria*, with fucoids, probably *Caulerpites*.

Chester Beds.

Syn. Ferruginous sandstone (Mo. and Tenn.) Mill-stone grit (or *whet-stone* grit. Dr. D. D. Owen).

This formation, No. 27, occupies the stratigraphic position of the Chester limestone of Illinois, but all calcareous material is here absent, as is the case in the more northerly exposures of that State. It consists of yellow or cream-colored, thin bedded sandstone with bands and nodules of clay iron stones; to the north and east of Independence, changing to shales and soft argillaceous sandstone. These

beds are well exposed on Redwood, a short distance above its mouth, and thence west and east underlie the massive sand rock, with a thickness varying from 20 to 44 feet. This is the equivalent to the famous "whetstone grits" in Orange county, and will furnish good sharp whetstones or fine grained grindstones. This stone north of Independence at the Attica quarries, Keeler's quarry, and Jones' quarry on Redwood, is taken up in slabs from two to ten inches in thickness, and may be easily cut or broken into any desired shape. At the last mentioned quarry, the rock is homogeneous and entirely free from iron, and may be readily sawed into door and window caps. This location invites the attention of workers in stone.

No animal remains were found in this deposit, but trunks and leaves of carboniferous plants, as *Lepidodendra, Stigmaria, Cordaites*, and *Calamites*, were seen.

CARBONIFEROUS PERIOD.

At the close of the sub-carboniferous period, a bed, No. 26, of dark pyritous clay, containing coal plants, was deposited unconformably and irregularly upon the upper members of that group. On exposure to air it rapidly decomposes, washes away, and gives origin to caves, cascades, and the "rock houses" common in Kentucky and southern Indiana. In the latter region it is often accompanied by a thin seam of coal. Here no coal was found exceeding two inches thick, and a single band of black slate at Munson's old mill on Little Pine.

Conglomerate Sandrock.

Syn. Millstone Grit—English Geologists.

The Massive Conglomerate, Nos. 24 and 25, lies upon the sub-carboniferous group, and in the surface outcrop, occupies a zone immediately west of the line bounding that formation. In the northwestern part of the county outliers are found capping the highest tables, as at Black Rock and near Milford. It extends westerly with a very slight dip to the west bank of Pine Creek, where the dip to

west and southwest is suddenly increased to the rate of from 20 to 30 feet per mile. Southerly along the line of strike, Pine creek flows in a deep valley, generally walled by bold mural escarpments or overhanging cliffs of massive sandrock, crowned with evergreen pines, cedars and junipers, combining scenery at once grand, wild and beautiful. The valley is from 150 to 200 feet deep, and the narrow margin of alluvial soil was originally crowded with a tangled mass of thorny brush, briars and vines. These features made Pine creek a strong line of defense in Indian warfare, well suited to their strategy, and in the campaign of 1811 the confederated tribes planned to fight here with Harrison's army. The gallant general avoided their ambuscade, and by a quick march to the left flank, crossed higher up, to the open prairie, and ended the war by the brilliant victory at Tippecanoe.

The conglomerate is well developed along both sides of Pine creek, on Kickapoo, at Williamsport, and in the bluffs near the mouth of Redwood creek, a short distance below which, it crosses the Wabash to return in a sharp spur or narrow ridge near the I., B. & W. R. R. "stone cut," northwest from Covington. This formation consists of massive, variously colored sandstone, and rarely presents the typical character from which the name is derived, but near the mouth of Kickapoo, at Black Rock, and at Thompson's quarry near Milford, specimens full of pebbles are found. Generally it is a coarse grained ferruginous or micaceous sandstone, which may be quarried in blocks of any size desired. It may be split or cut freely when fresh from the quarry, but hardens on exposure to the air, and offers, in unlimited quantities, a building material usually fireproof, and whose capacity for resisting the elements, can be measured by computing the ages required by the river to cut its bed down from the top of Black Rock or Williamsport hill to the present channel, 140 feet below. The stone presents an agreeable variety of colors, varying from a gray or brown on Redwood creek, or gray, yellow and straw color at Williamsport, or white, gray and red, (including

the "bar stripe" and "bleeding stone") on Pine creek, to black, red and yellow, near Milford. When the quality and beauty of this stone is fully investigated, we believe that it will command the attention of railway managers and capitalists.

No animal remains are found in this rock. No signs of life, except the broken and worn trunks of *Lepidodendra, Calamites, and Sigillaria.*

COAL MEASURES.

The coal measures occur next in order of time. They lie directly upon the conglomerate, and in outcrop occupy the regions south and west of that deposit; in area more than one-half the county.

Near the top of the conglomerate, and capped by one of its heavy bedded members, is the horizon of coal A. No. 23 general section. This seam varies from a mere parting, to rolls and balls in local pockets, from one to two feet thick, as at Bizer's on Rock creek. It is not seen in the county of workable extent; but is of practical importance only as a plane from which to compute the relative position of the other coals and strata.

The thick bedded and flaggy sandstones, Nos. 21 and 22, are fine grained, often ferruginous, and at many points quartzose, as if compacted by the breakers of a stormy sea bursting upon a rocky islet or promontory. Here was found the reptilian tracks which Prof. Cox has designated by the name of *Collettosaurus Indianaensis, Nov. Sp.* See plate and description at the end of this county.

No. 20, a bed of black clay shale, with bands and massive boulders of argillaceous and calcareous iron ore is highly carbonaceous, and occupies the horizon of the rich beds of block coal in Clay county, yet it does not offer any distinct seam. It is barren here as it is found to be in Martin, Dubois, and other counties in southern Indiana. Specimens of the iron ore from all the workable outcrops were secured for the State Cabinet; and for analyses of ores from the mouth of Fall creek, Dix's mill, and Cedar bluff, I refer to the chemists' report. These ores are abundant, judging

from the outcrop, rich and mixed with the best ingredients for fluxes, offer a combination of desirable qualities rarely met, and which will at once invite the attention of iron masters when facilities for transportation are secured.

Coal K., with its companion strata, Nos. 16 to 19 of fire clay, black slate, and superincumbent bituminous limestone, succeeds next. These strata, on account of the readiness with which they may be identified, are an important horizon in the geology of Indiana. Their line of outcrop may be traced from near the Ohio river, in Dubois and Pike counties, to the middle of Warren county; and have been recognized by Professor Cox in all the intermediate region almost uninterruptedly. The limestone roof is even more persistent than the coal itself. Consequently, when the coal may be eroded or the conditions such that a true seam was not developed, the place of K. can at once be determined from the occurrence of the lime rock.

K., No. 18, is usually a thick seam of rich, strong, caking coal. As it approaches the margin of the coal basin, it is changed to "semi-block," and at or near the edge of the basin it universally becomes in part, or entirely, block coal —subject to the above mentioned conditions in Warren county the seam is found in the southern parts as in the lower seam on Possum run, at Adamson's, at the Steely farm and at J. Brigg's to be good to choice semi-block, ranging from 2 to 3½ feet, and averaging 3 1-6 feet thick. On Fall creek at all the banks, seam K. is a choice block coal, free from sulphur, well suited for smelting iron, and with an average thickness of over 3 feet.

No. 16, the dark bituminous limestone roof of K., is almost invariably present, ranging from one to four feet, sometimes changing to a calcareous shale. It is well developed at Mains' mills, on Redwood, where huge blocks are laid bare in the bottom of the creek. Here the stone is highly colored, homogeneous and compact. Specimens have been dressed by workmen. It will receive a high polish, and presents a striking appearance. Locally it is known as "Black Marble." In the lower division of this rock the

following fossils were found, viz: *Spirifer cameratus, S. lineatus, Athyris subtilita, Productus simireticulatus, P. cora, P. costatus, P. longispinus, Chonetes variolata, Lophopyllum proliferum, Pleurotomaria, Natica, Macrocheilus, Phillipsia scitula* (13 in one cluster), Crinoid stems and plates, with teeth and bones of the shark, *Helodus carbonarius.*

The clay shales, No. 15, and ferruginous sandstone, superimposing the "black" limerock, sometimes change into quarry sandstone. This is of no economic importance in this county, which is so well supplied with the conglomerate.

Coal L., No. 13, of general section, offers a greater number of outcrops than any other, and consequently is better known. Presenting the characteristic features seen in other parts of the State, it is a lustrous, laminated, caking coal, rich in carbon, burns to a white ash, and furnishes a first rate fuel for locomotive, rolling mill, or other steam and household use at Briscoe's, Tinkler's, and Harold's mines near Lebanon. At Hooper and Barringer's on Possum run, the product is a good article of block coal, and nearly as good at Luppolds' bank on Fall creek, and in the thin outcrops on Adamson's land, in the extreme southeast corner of the county.

The space between coals L. and M., No. 11, as usual, consists of soapstone and clay shales, changing to argillaceous sandstone. These beds are often crushed and manufactured into potters and terra-cotta ware. The lower member, No. 12, is almost invariably crowded with leaves, fruits, and trunks of carboniferous plants in a remarkable state of preservation. No station in the State can equal in variety and perfection the beautiful specimens found at Briscoe's, West Lebanon shaft, at Tinkler and Harold's near Lebanon, and at I., B. & W. R. R. cut near Covington. The following is a partial list:

Lepidodendra (4 sp.), *Ulodendron, Sigillaria* (2 sp.), *Stigmaria, Megaphytum* (?), *Neuropteris* (2 sp.), *Pecopteris* (2 sp.), *Odontopteris, Alethopteris,* (2 sp.), *Asterophyllites*

(2 sp.), *Cordaites* (2 sp.), *Hymenophyllites*, with seed spores, *Cardiocarpa*, *Paleoxylon*, and *Sphenophyllum Schlotheimi*.

Coal *M.*, No. 9, of section, is a fat caking coal, containing much sulphur. Outcrops were seen on Mud Pine at Briscoe's, and at Wilson's bank on the head of Fall creek, the product at this point meeting a ready market. The seam ranges from six inches to one and a half feet, and will hardly average sixteen inches thick. The roof of M. generally consists of a black, pyritous slate, lean iron stones, and concretions of argillite, of no economic importance as far as visible in the outcrops. The highest rocks seen in the county are next, No. 6 of section; generally shaley, this bed is of sufficient consistence at a few points to afford quarry rock and grits for grindstones.

The foregoing presents the general geology of the county in a connected view. To this will be added detailed sections—representatives of each neighborhood for local information.

LOCAL DETAILS.

Williamsport, the county seat, is situate on the west bank of the Wabash river. Since the construction of the T. W. & W. Ry., the town has extended up and over the bluff to the railway station. A large amount of pork, corn and wheat was shipped from this place, when the early citizens, using "God's free highway," floated their commodities to New Orleans. Considerable shipments are made by rail of live stock, grain, timber and stone. Near the crest of the hill, nearly 100 feet above the river valley, the new court house is seen, trimmed with gray and cream colored conglomerate sandstone, obtained from quarries belonging to Hon. Ben. Gregory and Dr. Boyer, in and adjoining the town; massive in style of architecture, it presents an attractive and commanding appearance. This structure as a demonstrative experiment, showing the quality and appearance of the sandstones which are so abundant in the vicinity, is alone worth its cost. The stone comes from the quarry

soft and easily dressed, hardens on exposure, may be obtained in blocks of the largest size, and could be cheaply quarried and shipped if a railway track was laid to the quarries above or below town. The different strata vary from brown or gray to a delicate straw color. Blocks are thus obtained which contrast in a pleasant but striking manner.

This rock dips to the W. S. W., at about 70 feet, and to the south at the rate of 40 feet per mile. The following section commences near the railway station, and is continued to low water in the river, including the limestone at the iron bridge and the calcareous shales in the lower part of town:

SECTION AT WILLIAMSPORT.

Soil	1 to 4.00
Gravel, loose Sandstone or drift	5 to 23.00
Gray shale with iron nodules	2.08
Sandstone, flaggy, ferruginous	16.00
Bit. shale or coal A	.04
Fire clay or Argil. Sandstone	2.00
Laminated Quartzose Sandstone	8.00
Soft yellow ferruginous Sandstone	20 to 5.00
Massive conglomerate	50.C0
Compact ferruginous Sandstone	12.00
Blue aluminous shale with *Cordaites*, *Calamites*, *Lepidodendra:* highly bituminous and pyritous with partings of coal; place of sub-con glomerate coal	5 to 18.00
Covered space	7.00
Thin-bedded Argil. Sandstone and "grit" stones, (Chester formation of subcarboniferous group) with *Lepidodendra* and *Stigmaria*	17.00
Limestone, changing to calcareous sandstone, containing the screw shaped axes and lace-like flanges	

of *Archimedes Wortheni, Productus tenuistriatus* (cora ?), *P. muricatus*, P. *punctatus*, P. *semireticulatus*, *Chonetes*, *Athyris*, *Hemipronites crenistria*, *Spirifer Keokuk?* *Sp. plenus*, ?. *Aulopora*, and a *Bellerophon* sp. ?, *Rhynchonella?*, many *Crinoid* stems, plates and spines, stems of *Pentremites* in fragments, and corals............................	2.00
Siliceous shale and soft laminated sandstone, containing *Fucoides* and *Bryozoans*	5 to 22.00
	188.00

Owing to the rapid dip of strata to the west, this section taken across the tilted edges, and perpendicular to the dip, shows, consequently, a greater thickness than the actual elevation of the hill.

The fossils mentioned in the limestone or calcareous sandstone are sub-carboniferous, and *experience demonstrates that no workable coal seam of economic extent ever has been or may be found below the horizon of the rock containing the fossil Archimedes.*

Near the railway station, Fall branch plunges from the summit of an overhanging mass of rock down sixty feet to the valley, and has thence cut a narrow outlet to the river, affording a first rate section of the conglomerate sandrock in massive strata from twenty to forty feet thick. Here a choice quarry is worked on the land of B. F. Gregory. A large amount of stone is sold, and the business might be greatly increased if better access to the quarry was secured by rail or tram-way. As mentioned in general outlines, it is probable that in the early ages, the Wabash or Pine creek, at a high level, flowed through this gap and thence south. At that time was formed the valley and terrace plain along the railroad, widening southward to Rock creek.

Adjoining town on the south are several localities easily approached by a railway track, where good stone may be quarried at little expense for stripping.

On Dr. Boyer's land S. E. ¼ Sec. 11, T. 21, R. 8, is a small cascade. The water, at the time of my visit, fell in spray or drops. In winter this congealed spray forms fairy grottoes of ice and frost. A spring close by is locally known as the "Sulphur Spring." The ferruginous tufa shows that it is chalybeate. Analyzed by Prof. Cox, (Geol. Ind. 1869, fol. 130), its principle constituents are

Sulphate of protoxid of iron,
Carbonate of protoxid of iron,
Bicarbonate of lime,
Bicarbonate of magnesia,
Chloride of Sodium (common salt),
Sulphate of soda, (Glauber salts) small quantity,
Sulphate of magnesia, (Epsom salts) small quantity,
Free carbonic acid gas.

The medicinal properties of this will be of value, in cases where iron is indicated. High up on the side of the hill, half a mile south-west from the spring a considerable bed of kidney and banded iron ore was seen. The quantity on the outcrops was considerable, and the deposit merits examination. A specimen was taken for analysis.

Dr. Boyer informs me that he bored three test wells, 2½ miles west of town, near the line dividing sections 3 and 4, T. 21, R. 8; in one of them near the center of N. E. ¼ Sect. 4, T. 21, R. 9, the workmen reported a seam of splint coal 3 feet thick, at a depth of 81 feet. Three miles west of Williamsport, on S. ½ N. E. ¼ Sec. 5, T. 21, R. 8, Mr. O. Swank reported 3 feet of coal found in a bore 82 feet below the surface. Spears, Brown & Co., put down test bores on the following lands, viz:

E. Briggs, S. W. ¼ 8. 21. 8.
E. Slusser, N. E. ¼ 8. 21. 8.
J. Etmyer, N. W. ¼ 5. 21. 8.

And reported having found three seams of coal, but none of them thicker than fifteen inches.

The following section was taken on the land of S. B. Mathes, where the Williamsport and Lebanon road crosses Rock creek. The bituminous limestone indicates the place of coal K. The carbonaceous material of the seam is diffused through the black shales below:

Rock Creek Section.

S. E. Sec. 18, T. 21, R. 8.

Slope	3 ft. 00 in. to 12 ft. 00 in.	
Shaly, argillaceous limestone	2 ft.	8 in.
Black bituminous limestone containing *Spirifer cameratus*, *S. lineatus*. *Productus semi-reticulatus*, and *Chonetes mesoloba*	4 ft.	6 in.
White clay parting		8 in.
Place of coal K:		
Carbonaceous pyritous shale	1 ft.	4 in.
Blue Argil. shale	1 ft.	2 in.
Black carbonaceous and pyritous shale	3 ft.	2 in.
Calcareous iron ore with *Spirifer lineatus* and *Productus costatus*		6 in.
Dark bituminous shale	2 ft.	8 in.
Impure black sheety slate	1 ft.	2 in.
Dark bituminous shale	4 ft.	6 in.
Blue and gray shale	17 ft.	00 in.
Light colored shale and soapstone	5 ft.	00 in.
Flaggy sandstone	15 ft.	00 in.
Coal A	2 ft. 00 in. to 00 ft.	2 in.
Fire clay	8 in. to 2 ft.	4 in.
	73 ft.	10 in.

The horizon of coal A, is here 55 feet higher than it is found on Dr. Boyer's land south of Williamsport and three miles to the east of this point. The dip there was to the west; here also to the west. These facts show that intermediate a synclinal axis exists. Rolls and sharp waves of such intensity almost forbid hope of workable coal between these points.

On the slope at the top of the section is an old cemetery. Family reasons required the removal of the remains of a woman who had been buried here in the month of March, 24 years ago. The person had died in full flesh. A wet season followed. From the dip of the underlying tenaceous clay and rocks, the grave was kept full of water during the succeeding summer; in fact, one of the assistants expressed his opinion that "the grave would be full of water within three hours after the burial." On opening the coffin, it was found that the body was perfectly preserved, except the upper part of the face, the hands which were crossed *upon* the body, and the upper part of the feet. The body was heavier than in life. The skin was smooth and firm, with a clear transparent whiteness like alabaster. It was generally believed that the corpse had become changed to stone, and a paragraph went through the papers announcing a graveyard full of *Petrified human remains.*

The foregoing phenomenon is explained by the fact that flesh of any animal covered with cool water for several months undergoes a chemical change. First, decomposition commences; ammoniacal gases are formed, which in attempting to escape, are confined near the surface of the flesh or skin by the water. The alkaline gas has affinity for the fatty matter with which it comes in contact, and there is formed ammoniacal soap—*Adipocere.* This substance resembles *spermaceti,* and is not soluble in water.

Another person died in full flesh the same year that this woman died, but was buried during the dry season of autumn. Upon opening this grave for removal, the body was entirely decayed; showing that water was necessary to

produce the seeming wonder. A similar phenomenon occurred in a damp cemetery near Marshfield.

Coal A. has been explored to some extent on David Biser's land, N. E. qr. Sec. 19, T. 21, R. 8. It is deposited in irregular rolls or waves, which vary from 6 to 10 feet from a horizontal line within a space of 300 yards. The pockets of coal are small, and will not be likely to pay for working.

South of Biser's, on land of Mrs. J. Bowlus, W. hf, S. W. qr, Sec. 20, T. 21, R. 8, is a valuable bed of calcareous tufa, which would furnish a considerable amount of good lime. As the lime used in the county is imported, this deposit ought to be utilized.

Near Mains' mill on Redwood, the creek is floored by dark limestone, locally known as "Black Marble." The stone is four feet thick, compact, homogeneous, and is divided into massive blocks by seams running E. N. E. and N. N. W., thus forming huge rhombs. The "marble" is capable of receiving a high polish; it contains some pyrite minutely diffused, and care will be required in selecting stone for the workmen; otherwise it will be liable to tarnish, etc. In a lower member was found *Productus costatus*, *P. cora*, *P. longispinus*, *Spirifer cameratus*, *S. lineatus*, *Athyris subtilita*, *Chonetes mesoloba*, *Macrocheilus fusiformis*, *Natica*, *Lophophyllum proliferum*, palatal teeth of the shark *Helodus carbonarius*, fish bones, Crinoid stems and plates, and a family cluster containing thirteen specimens of *Phillipsia scitula*. The best polished blocks of this marble, I am informed, were obtained from the Hasty land, N. E. qr, N. W. qr. Sec. 35, T. 21, R. 9.

The following section was taken at and below Mains' mill, viz:

REDWOOD SECTION.

Slope......................................	
Black limestone with fossils...	4 to 2 ft. 6 in.

Black slate........................	2 to	3 ft. 0 in.
Carbonate of iron with *Productus longispinus*............		4 in.
Place of Coal K..................		
Black bituminous slate, with pyritous nodules..............		5 ft. 5 in.
Bituminous limestone...........		9 in.
Quartzose sandstone.............		2 ft. 0 in.
Carbonaceous parting, place of Coal A.........................		
Laminated sandstone		12 ft. 0 in.
		26 ft. 0 in.

The places of coals A and K are well marked, as at Rock creek section, but the carbonaceous material probably sufficient in quantity if collected together to form seams of workable extent, is here diffused through a space of several feet, and is represented by dark bituminous slate and shales. At other points, as at the mouth of Fall creek on Pine, a similar state of affairs is found; yet within a mile to the west, Coal K of workable thickness and of excellent quality occurs. Hence, we may deduce a *possibility*, if not a probability, that coal K may be found of workable extent, by boring within a mile or two west of these two section stations.

Passing down the creek from Mains' mill we at once notice the rapid rise of strata to the east. The dark limestone and beds marking the place of coal K, mount the sides of the hills at the rate of about 90 feet per mile, and soon pass out at the surface. The underlying conglomerate rises above the level of the creek, and bounds the valley with perpendicular walls of massive sandstone, and at one place its square face was tinted by ferruginous water trickling from above, with brown, red and yellow stripes, rivalling in a small way the "Painted Rocks" of Lake Superior. The conglomerate passes out at the surface, succeeded by the soft laminated sandstones of the upper, or "Chester," beds

of the sub-carboniferous group. The latter, as quarried, may be cut with ease. Experience shows that this stone furnishes good door and window caps. Specimens were seen at Jones' quarry sawed by hand. During the winter and spring months the creek, with appliances, could be made to saw this stone with profit.

On Salts branch, W. H. Goodrick is working a strip bank on N. hf. S. E. qr., N. E. qr., Section 3, T. 20, R. 9. The deposits usually found between coals L and M have here been eroded previous to the deposit of coal M., the erosion thinning to some extent the lower seam.

SECTION AT GOODRICK'S BANK.

Soap stone with fern leaves		1 ft.	2 in.
Black sheety shale			5 in.
Black bituminous shale			10 in.
Coal M. fat, caking, sulphurous		1 ft.	6 in.
Fire clay with stigmarial rootlets		2 ft.	2 in.
Black clay clod, with "*Cone-in-cone*" and pyrite		1 ft.	3 in.
Coal L			
Fair laminated coal	1 ft. 5 in.	3 ft.	2 in.
Good coking coal	7 in.		
Pure blacksmith coal	1 ft. 0 in.		
Fire clay		2 ft.	0 in.
		11 ft.	6 in.

Tinkler & Co., representing the West Lebanon Coal Co., work the same seam by stripping and by slope on J. Miller's land, W. hf. N. W. qr. Sec. 2, T. 20, R. 9. This coal is reported to give satisfaction wherever used. A quantity was hauled to Lebanon for sale and shipment by rail.

In the S. W. qr. Sec. 2, T. 20, R. 9, a section was taken, commencing on Wm. Salts' land and closing irregularly at the foot of the hill on Geo. Long's land.

SALTS-LONG SECTION.

Slope		
Gray shale....................	6 ft.	0 in.
Black bituminous shale....	0 ft.	7 in.
Coal M.......................	1½ ft. to 1 ft.	0 in.
Fire clay with Stigmarial rootlets.....................	3 ft.	4 in.
Siliceous shale, yellow	1 ft.	4 in.
Soapstone, with iron nodules containing *zinc blende*	2 ft.	6 in.
Soft bituminous shale......	1 ft.	2 in.
Coal L.......................	4 in. to	10 in.
Fire clay	3 ft.	8 in.
Buff and yellow shale......	7 ft.	0 in.
Flaggy grindstone grits...	2 ft.	2 in.
Buff shale.....................	1 ft.	6 in.
Gritty sandstone and covered	17 ft.	0 in.
Black limestone at Long's residence	3 ft.	0 in.
Blue and black shale.......	7 ft.	0 in.
Coal K, reported *block*.....	1 ft.	6 in.
Fire clay.....................	3 ft.	0 in.
	62 ft.	7 in.

Coal was formerly mined by stripping in N. E. qr., Sec. 10, T. 20, R. 9, known as the "Steely farm," and on lands owned by Salts, Long, Briggs, Miller and Fields, for a space of about three-fourths of a mile along the river bluff. The coal was supplied to steamboats on the river. The seam ranged from one and a half to two feet thick. The banks were not in work. The fragments seen were fair to a good article of block coal.

In N. E. qr. N. E. qr. Sec. 9, T. 20, R. 9, on the land of Levi Cronkhite, Messrs. Harrell, Cronkhite and Garrison, known as the Marshfield Coal Co., are working coal L by stripping on a sufficient scale to supply the large local trade

Their coal is a splendid article, bright, lustrous, free from dust, and burns to a white ash. Fragments were seen almost as pure and resinous as the Nova Scotian *Albertite*. Their location gives the following section, viz.:

MARSHFIELD COAL CO.'S SECTION.

Slope—Fluviatil and glacial drift....................		95 ft. 00 in.
Coal M—not worked.....		1 ft. 8 in.
Fire clay......................		2 ft. 6 in.
Soapstone		2 ft. 4 in.
Soapstone, Fern bed containing *Cordaites* (2sp.), *Calamites*, fern stems, *Pecopteris* (2sp.), *Neuropteris hirsuta*, *N. rarineris*, *N. Collinsii*, *Annularia longifolia* and *Sphenophyllum Schlotheimii*		1 ft. 9 in.
Dark soapstone..............		2 ft. 00 in.
Carbonaceous clod—imperfect coal.................		1 ft. 1 in.
Coal L........................		
Caking coal............	7 in.	2 ft. 8 in.
Laminated coal.........	9 in.	
Fat resinous coal......	1 ft. 4 in.	
Fire clay		4 ft. 0 in.
		113 ft. 0 in.

This locality may be noted for the abundance, singular perfection and beauty of the plants found in the "fern bed." Specimens of *Neuropteris hirsuta* four to six inches long, were seen, with the small lobes at the base of frond, attached; also flattened trunks of *Calamites* and ribbed leaves of *Cordaites borassifolia*, ornamented with the delicate

Gyromices ammonis, described by Professor Lesquereux in Geology of Illinois vol. II.

On Coal branch a short distance southeast from the Marshfield mine, Claypool works coal L by stripping. The product is a good caking coal, which burns to a white ash. The seam is two and a half to three feet thick, with outcrops similar to the foregoing section. Descending the branch, the seam dips to the east, nearly to the bluff line, with the fall of the brook. The dip is then reversed. Throughout the intervening space the seam may be traced, and a careful observer will notice that the coal was deposited in waves or rolls, from 50 to 150 feet in width, thickening well up at the centers of depression, but thinning to a thread at the wave crests or horse backs. Mr. Claypool has driven entries into several of these small wave pockets without satisfactory results. Features similar to those above mentioned are observed at Cannelton, Perry county* and north of Briscoe's mine on Mud Pine.

On Possum run, Section 8, T. 20, R. 9, Hooper and Barringer, of Danville, Illinois, noticed the presence of "block coal" in "prospecting." They secured control over a sufficient territory, and at once thoroughly explored their property by boring twenty-five (25) test wells. Finding coal from two, to three feet two inches thick in each, of their wells (except three, which were located on the west side of the brook), they proceeded to put down a shaft close by the track of Indiana division of the C. D. & V. railroad. At a depth of 25 feet coal L was found of workable thickness, and thirty-four feet below L, coal K was met, having a depth of three feet two inches. I am indebted to Mr. Hooper for the following statements of strata at shaft, viz:

HOOPER & BARRINGER'S SHAFT AND BORE.

Possum Run N. E. qr., Sec. 8, T. 20, R. 9.

Soil	3 ft. 0 in.
Yellow clay, with float coal	9 ft. 0 in.

* Lesly's Manual.

Soapstone, changing to argil. sandstone	12 ft.	6 in.
Soapstone, Fern bed containing *Lepidodendra* (bark and leaves), *Calamites*, *Sigillaria reniformis*, *Annularia longifolia*, *Asterophyllites equisetiformis*, *Sphenophyllum Schlotheimii*, *Pecopteris*, and *Cordaites borassifolia*	2 in to	6 in.
Coal L, block	2 to 2 ft.	8 in.
Fire clay	3 ft.	6 in.
Rock in bore	25 ft.	3 in.
Hard limestone	3 ft.	0 in.
Coal K	3 ft.	2 in.
Fire clay	2 ft.	4 in.
	64 ft.	7 in.

Owing to circumstances I did not pass down the shaft. A quantity of coal at the dump showed that the product of L here contained but a small amount of sulphur, and was good block coal well suited for smelting iron. The sulphur is mostly gathered in a small parting one foot above the bottom of the seam, and may be separated in mining. The coal is very compact in its lower division, but laminated and softer at the top. It burns to a white ash. The seam is divided into cubes one and a half to two feet square, with clay and lime whitewash in the partings, as in Clay county. It may be mined in large blocks. Mr. Barringer informs me that from the bottom of the shaft an entry has been driven to northeast 150 feet, the coal holding an average thicknesss of three (3) feet. Within that distance two "horse backs" (wave crests) were passed, but so close together that they may be held as parts of one—both not occupying more than 45 feet; the first was three feet and the second thirteen feet wide, with an intervening space of twelve feet. Mr. Barringer reports that the coal throughout the whole extent of their work, presents a quality of block coal fully equal to the product seen at the dump. An average specimen

was secured for analysis (see chemist's report), and exhibition in the State Cabinet.

The fire clay in the shaft is buff or gray, plastic, and after exposure to the atmosphere will prove suited to the manufacture of pottery, tiles and terra cotta wares. The clay has been shipped to Chicago for trial, but I am not informed as to the results.

I was informed that a shaft was put down on Mr. John Gilman's farm, S. E. qr., Sec. 8, T. 20, R. 9, adjoining Hooper & Barringer, on the west side of Possum run, to coal L. I did not learn the result.

On Adamson's farm, S. E. qr. Sec. 27; T. 20, R. 9, is a mass of conglomerate sandrock, forming the bluff of the river, eminently chacteristic of that stone. Quarried, it has been used for bridge piers, fire-walls, and for hearth-stones at Indiana Furnace at Clinton. This deposit is the termination of a sharply angular spur, boldly piercing the coal basin from the old conglomerate hills which then existed east of the Wabash. Cross-currents swept this headland, and deposited wedge-shaped layers on each side with some carbonaceous matter. This process was repeated; more wedge shaped plates were deposited, rounding the sharp apex into a flattened dome, where we find coal K. A bed of laminated argillaceous sandstone follows, and then coal L is arched over the hill. A similar phenomenon occurs on Mud Pine, north of Briscoe's bank, and at the west end of Dix's mill dam, on Big Pine. In the adjoining cut of the I., B. & W. R'y, were found fine specimens of ferns, plants and fruits of coal measure epoch.

SECTION AT ADAMSON'S COAL DOME.

Soil and gravel............	2 ft. 00 in. to 10 ft. 00 in.
Fine laminated sandstone argil........................	10 ft. 00 in.
Soapstone and gray shales with ferns................	6 ft. 00 in. to 00 ft. 8 in.

Coal L? semi-block........		1 ft. 10 in.
Fire clay, *roots and stumps of Stigmaria*.............		3 ft. 6 in.
Heavy bedded — slightly wedged, and flaggy sandstone................		29 ft. 00 in.
Calcareous, ferruginous band........................	6 in. to	1 ft. 8 in.
Coal K?.....................	6 in. to	1 ft. 2 in.
Fire clay.....................	2 in. to	4 ft. 00 in.
Beds of wedge shaped sandstone with carbonaceous partings..........		20 ft. 00 in.
Massive conglomerate.....15 ft. 00 in.	to	9 ft. 00 in.
		90 ft. 5 in.

The crown of this coal measure hill has been partially eroded by drift action, and upper spaces are measured at lower levels in I. B. & W. railway stone cut. The spring of these arched strata will measure about 20 feet in a chord of 500 feet.

No outcrops are visible near State Line City, or at Marshfield. The intervening region consists of undulating prairie, with skirts and heavy bands of oak, sugar and other forest trees to the east. A fine growth of walnut was noticed at Gopher Hill, the farm of Perrin Kent, Esq.

West Lebanon is a thriving village situated on the line of the T. W. & W. railway at the crossing of the proposed railroad thence north to Michigan City. It is surrounded by fertile and productive lands. A well, bored for water in the western part of town, discovered at a depth of 150 feet a seam of coal having a reported thickness of three feet. The citizens formed a mining company, and sunk a shaft to a depth 149 feet, passing through two seams of coal and by bore demonstrated the existence of a third seam at a total depth of 183 feet. I am indebted to Joseph Bauer, superintendant, for the following stratigraphic report.

SECTION IN WEST LEBANON SHAFT.

Soil and clay	20 ft.	0 in.
White, yellow and black sand pocketed in clay, with sandstone fragments	12 ft.	6 in.
Glacial blue clay and gravel	17 ft.	0 in.
Dark clay, with sandstone and large granite boulders	25 ft.	0 in.
Blue and green clay with pebbles	14 ft.	0 in.
Black mould—roots of trees in *situ*,	0 ft.	2 in.
Dark clay and mucky soil filled with large limbs and roots of trees, apparently birch or pine	15 ft.	0 in.
Disturbed sandstone, with decomposed nodules of pyrites	6 ft.	0 in.

Coal M. Caking—pyritous—

Coal	0 ft. 8 in.			
Parting	0 ft. 4 in.			
Coal	0 ft. 8 in.			
	— —		1 ft.	6 in.
White clay and soapstones			1 ft.	8 in.
Soapstone containing *Lepidodendron clypeatum*, *L. arculeatum*, *L.* (2 sp. ?) Leaves of do., *Lepidostrobus*, *Sigillaria reniformis*, *S.* (sp?) *Ulodendron punctatum*, *Sphenophyllum Schlotheimii*, *S.* (sp?), Fronds of *Pecopteris*, *Alethopteris*, *Cordaites borassifolia*, and *Hymenophyllites spinosus*			5 ft.	2 in.

Coal L. Semi-caking.

Coal	1 ft. 0 in.		
Clay parting	0 ft. 10 in.		
Coal	1 ft. 0 in.—	2 ft.	10 in.
		—	—
		149 ft.	10 in.

Bore:

Fire Clay..................	5 ft. 0 in.	
Blue shale..................	6 ft. 0 in.	
Dark limestone, effervescing in acid.........	7 ft. 0 in.	
Black slate.................	5 ft. 8 in.	

Coal K.

Pyritous coal..............	0 ft. 9 in.	
Pyrite parting............	0 ft. 5 in.	
Coal	0 ft. 5 in.	
Carbonaceous concretion	2 ft. 0 in.	
Fire clay..................	2 ft. 0 in.	
Sandstone..................	4 ft. 0 in.	—33 ft. 3 in.
		183 ft. 1 in.

The partings and concretions found in these coals, rather indicate that the well was bored through a series of "horse backs," which are often known to preserve a perpendicular line through a series of coals. The truth as to this can only be known by additional bores, or by driving entries, not less than seventy feet, sidewise, or against the sides of the cubes of coal.

The fossil plants were abundant, well preserved, and an interesting chapter of nature's history of the past. The fronds of *Hymenophyllites* were tipped with just ripening seed spores. Many fern stems were seen from two to three inches in flattened diameter.

In the Indian Reserve, one mile east of Williamsport, Mr. Jordan has two quarries worked in the thin bedded argillaceous sandstones of the Chester formation, where the following section was taken, viz:

Shale and sandstone, slope............	20 ft. 00 in.
Limestone with Keokuk and St. Louis fossils...........................	2 ft. 00 in.
Thin bedded, quarry sandstone......	10 ft. 00 in.
	32 ft. 00

John R. Keeler works the "Attica quarry," southwest quarter, section 31, township 22, range 7; a thin bedded Chester sandstone. The strata thicken toward the bottom to beds of two feet. Good whetstones and finishing grindstones have been obtained here. Much building stone is quarried and sold.

On the north side of Pine creek, in the river bluff, is a deposit of the same formation, worked by Peter Hickman, with expose as follows:

HICKMAN'S QUARRY, SECTION.

Clay and soil..............................	4 ft. 00 in.
Sandstone in bands of 1 to 2 feet, parted by 2 in. to 4 in. of clay shale..	10 ft. 00 in.
Heavy bedded yellow sandstone, strata 2 to 4 ft..................................	15 ft. 00 in.
	29 ft. 00 in.

These lower beds are yellow colored, ferruginous, and the product bears a good reputation. It is used for piers and heavy masonry. In all these quarries the blue colored strata are argillaceous, and on exposure, liable to wear. An unlimited quantity of good stone may be selected from the enduring beds.

A short distance east from Hickman's quarry, the subcarboniferous rocks are sunk below the surface by a synclinal valley filled with conglomerate sandstone, which reaches down near the base of the hills along the bluff road.

On Mrs. Warwick's land Sec. ?, T. 22, R. 7, a small brook has worn a narrow chasm through the conglomerate, down to the shales below. The small stream descending a rapidly inclined plane, or leaping from strata of harder rock, flecks the dark recess of the chasm with a silvery sheet of water and foam. On the summit, ancient pines seem to wave their sombre plumage against the blue sky, and cast down their cones as an offering to the fay of the fountain.

The following section was observed, viz:

WARWICK CASCADE SECTION.

Incline....................................	
Thin bedded conglomerate, with pebbles..................................	10 ft. 00 in.
Massive congl. irregularly bedded...	40 ft. 00 in.
Dark bituminous shale with leaves, stems and trunks of coal plants...	10 ft. 00 in.
Blue and gray sub. carb. shale......	20 ft. 00 in.
	80 ft. 00 in.

A short distance east of the Warwick Cascade, and about two hundred and fifty yards west of Kickapoo mills, the subcarboniferous rocks again rise above the level of the bottom's road. Here the concretionary nature, often characteristic of the Chester beds, is exhibited in a highly interesting manner. A perpendicular wall of thin bedded sandstone guards the north side of the road. From the escarped face great spherical balls are projected in relief, four and and a half to five feet in diameter. A similar phenomenon was observed in the same formation on Redwood creek.

For a distance of from two to three miles from the Wabash in the valleys of Pine creek, Kickapoo and Little Pine, good exposures of the Chester sandstones are seen changing toward the north, to silicious and then to argillaceous shales or mudstones; at a few points nodules of iron ore and small quantities of zinc blende are present.

SECTION ON PINE CREEK.

S. W. Quarter, Section 26, Township 22. Range 8.

Drift..	40 ft. 0 in.
Conglomerate, quartzose sandstone...	2 ft. 6 in.
Shale, and bands of Chester sandstone..	19 ft. 0 in.
Thin bedded argil. Chester sandstone..	19 ft. 0 in.
Ferruginous argil. sandstone with geodes containing zinc blende...	8 ft. 0 in.
Blue shale to Pine creek..................	3 ft. 0 in.
	82 ft. 0 in.

At Gold branch of Pine creek, N. W. qr. Sec. 23, T. 22, R. 8, on a gravel bar formed of debris washed from the boulder drift, a quantity of gold, reported at $70, was collected. An energetic Californian can "pan out" from $1 to $1.25 per day at this, and several other gravel bars in the county. An equal amount of labor expended at any ordinary avocation, will bring better returns.

Independence is situated on the summit of a ridge or roll of Chester rocks, and the rapid dip of underlying strata, draining the porous soil resting upon them, causes an outflow of many strong springs. These rocks were once capped with outliers or regular beds of conglomerate. The latter was eroded by force of fluviatil or glacial currents. The resulting debris formed the terrace plain or "barrens" which surround the village for a space to west or southwest of one or two miles. Beyond this plain on Kickapoo and Pine Creek, the sandrock develops massive blocks and cliffs of good stone. On the hillsides, near Independence, bands of white chert occur, intercalating beds of sandstone and clay, and a heavy development of chert is reported across the river at Flint creek. At the road crossing, a short distance above the mouth of Little Pine creek, is an exposure ninety-eight feet thick, of blue arenaceous shales. In appearance they much resemble the Knobstone beds. No fossils were found. The stratigraphic position, and an underlying bed of chert and geodes, will, I think, justify the classification of this bed with the upper or middle member of the sub carboniferous group.

Black Rock, southwest qr. Section 9, T. 22, R. 6. is a notable and romantic feature in the river scenery. A precipitous or overhanging cliff exhibits an almost sheer descent of 140 feet to the Wabash at its foot. The top is composed of yellow, red, brown or black conglomerate sandrock, highly ferruginous, and in part pebbly. At the base of the sand rock where it joins upon the underlying carbonaceous and pyritous shales are, "pot" or "rock houses," which so constantly accompany this formation in southern Indiana. Some of these of no great height have

been tunneled back under the cliff to a distance of 30 or 40 feet, by force of the ancient river once flowing at this level.

SECTION AT BLACK ROCK.

Conglomerate	40 ft.	00 in.
Bituminous shale	12 ft.	00 in.
Blue and green argillaceous shale and soft sandstone, Chester, St. Louis, and Keokuk	83 ft.	00 in.
Knobstone shale	5 ft.	00 in.
	140 ft.	00 in.

From the top of this hill may be enjoyed a fine view, comprising the river winding through the beautiful valley to the southwest, eastwardly the Wea plains are checkered with fields of grain and grass, while frequent trains on the railroad play "hide and seek" in clumps of timber skirting the valley, and give life to the landscape.

Going north towards Milford, outliers, of conglomerate cover the tops of the hills and the table lands (beneath the surface deposits), while the deeper valleys present good exposures of the sub-carboniferous group.

At Bee run, on lands belonging to Chauncey's heirs, east half s. w. qr. Section 4; T. 22; R. 6, a party of strangers with a great air of mystery, made an extensive trench up the face of the bluff to the base of the conglomerate. The material cast forth showed that they had dug a few feet into the bituminous and the blue shale which lies just below the sand rock. This level is exposed at a dozen points on Bee run and Little Pine. No minerals were found; the explorers certainly had barren results.

At W. Gooden's tract, west half northeast quarter Section 4; T. 22; R. 6, near Tippecanoe county line, the following outcrop is seen:

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GOODEN'S CASCADE SECTION.

Slope....................................		
Conglomerate—pebbly, overhanging or cavernous, containing *Lepidodendra*, *Calamites* and *Cordaietes*..	25 ft.	00 in.
(Rock house shed,).....................		
Carbonaceous shale........................	2 ft.	00 in.
Sub-carboniferous shale, blue.........	20 ft.	00 in.
	—	—
	47 ft.	00 in.

Bones of men and animals found under the overhanging roof-rock, in a bed of ashes and calcareous tufa, showed that this rock house had once been inhabited. In the gorge below, beautiful ferns of many species were noticed, including quite a plat of the climbing fern, *Lygodium palmatum*.

At Sinaway Munson's old mill-seat, on Little Pine creek, is a thin bed of bituminous slate, with minute pockets of coal. There is no probability of finding a workable seam here.

MUNSON'S MILL SECTION.

Slope....................................		
Quartzose conglomerate resting on pebbly base...............................	4 ft.	00 in.
Carbonaceous and black sheety shale	1 ft.	8 in.
Quartzose and green shales with Spirifers and Bryozoans.................	20 ft.	0 in.
	—	—
	30 ft.	2 in.

Ascending the creek on the south part of Bestana Munson's farm, S. E. ¼ Sec. 5, T. 22, R. 6, a calcareous sandstone, containing a few characteristic sub-carboniferous fossils, as *Nautili*, *Sperifera*, (3 Sp.), *Allorisma*, *Athyris*, *Producta* (2 Sp.), an indistinct *Crinoid*, and *Calamites*, *Cordaites* and *Fucoides*, underlaid by a thin bed of small geodes.

In the N. E. ¼ of Sec. No. 5, at the eastern bluff of the creek, the following was secured, viz:

SECTION ON LITTLE PINE CREEK.

Bestana Munson's land.

Slope, with conglomerate Sandstone..	20 ft.	00 in.
Blue and buff colored Shales, with *Cordaites*..............................	45 ft.	00 in.
Impure limestone, with a few *Archimidean Bryozoa*, *Producta*, and *Spirifers*..............................	4 ft.	2 in.
Pink and greenish shale, with *Nautilus trematodiscus*....................	3 ft.	6 in.
Yellow Keokuk limestone, *Productus*, with spines 2 to 5 in. long, *Hemipronites crenistria* and *Spirifers*.....	1 ft.	2 in.
Soapstone and blue shale...............	16 ft.	0 in.
Band of Argil. iron ore, (lean)........	0 ft.	8 in.
Shale, with small geodes...............	2 ft.	6 in.
Argil. iron ore (lean)...........	1 ft.	0 in.
Blue shale..................................	4 ft.	0 in.
	98 ft.	00 in.

A slab covered with *Producta* showed *spines* of remarkable length and tenuity. Many of the fossils were partly geodised. The *Nautilus* (*Trematodiscus*) *digonus*, is believed to be of lower Knobstone type, like those found in the Goniatite bed at Rockford, Indiana.

"Falling rock cascade" is situated in the E. ½ S. E. ¼ Sec. 6, T. 22, R. 6, on land belonging to Orren Munson. A sheet of cold spring water, from the exposed top of the conglomerate, leaps 35 feet down to the bottom of a narrow chasm cut out by the brook. The precipitous and overhanging sides are fringed with long pendant masses of stalactitic or mossy tufa. Pine trees around the rim, make perpetual shade in this cool grotto. It is a favorite resort for pic-nic parties, and for the "basket meetings" of the United Brethren Church. The calcareous tufa, burned, would furnish a large amount of good lime. Quantities

broken from ancient points of deposit, were seen lower down the ravine.

SECTION AT FALLING ROCK CASCADE.

Conglomerate Sandstone................	15 ft.	00 in.
Sub-carboniferous shales and soft sandstone, with *Cordaites*, leaves of *Lepidodendra*, and *Neuropteris*. ...	25 ft.	00 in.
Same, with iron nodules of large size and fair quality........................	5 ft.	00 in.
	—	—
	45 ft.	00 in.

Milford is situated upon elevated table land, and presents an air of thrifty life. Here is located "Green Hill Seminary," under charge of the church of the Brethren. One and a half miles south-west of the village, is an easily accessible quarry of conglomerate sandstone on the land of J. B. Foster, N. W. ¼ Sec. 32, and G. W. Thompson, N. E. ¼ Sec. 31, both in township 23, N. R. 6; small beds of pebbles in bands are seen in the upper layers, with sporadic pebbles throughout. This stone when quarried is soft, apparently disintegrating, but on exposure hardens and becomes almost as compact as limestone. Even fresh from the quarry, as tested, will bear the burden of bridge piers and heavy structures and may be obtained in blocks of as large size as can be managed. The exposure is continuous for half a mile along Schoolhouse branch, exhibiting a wonderful variety of bright colors, as red, brown, black, yellow, and gray; the more vivid colors predominating. Several layers are beautifully striped, the result of false bedding, by straight, clean cut red lines crossing the plane of deposition at angles of 30° to 45°. The stone has been tested for foundations, back-walls and hearth-stones, and, I am informed, is found to be fire and weather-proof.

The following section was taken at Geo. W. Thompson's quarry, and thence along the road, leading south to the top of the hill:

RED AND STRIPED SANDSTONE QUARRY SECTION.

Red sandstone, heavy bedded		52 ft.	00 in.
Covered........................		4 ft.	00 in.
Soft, gray sandstone	3 ft. to	2 ft.	00 in.
Brown sandstone.............		3 ft.	00 in.
Banded pebbles..............			3 in.
Red sandstone................		5 ft.	00 in.
Brown and striped sandstone		3 ft.	6 in.
Yellow ferruginous sandstone		4 ft.	00 in.
		—	—
		73 ft.	9 in.

It is believed this quarry will invite the attention of dealers in ornamental stone for heavy masonry.

Passing the splendid grazing grounds and well selected and fattened herds of James Mather, we find Pond Grove situated well in the northeastern corner of the county. Near the center of this grove was a body of water known as "Cranberry Pond." The lakelet was surrounded at the shallow outskirts by a natural growth of cranberry plants, including the "long vine," which bears oblong berries, and the "short vine," which bears sphere-shaped berries. Good crops followed a wet June, or the reverse. The maximum crop, in a favorable year without any care or attention, I am informed by Mr. T. D. Chenoweth, would measure not less then seventy bushels, ranging down to ten bushels per acre. About two hundred acres were formerly in productive vines. The pond is now drained. Berries are no longer produced. This is a public calamity, as a crop of berries, worth from $50 to $300 per acre, yields a greater income than may be realized from any other production. In places like this and others in the vicinity of Pine village, naturally suited to the growth of the vine, its cultivation in a systematic manner, would certainly offer better returns than are realized from the expensive plantations made on the high priced lands of Rhode Island and Massachusetts.

Pine village is surrounded by a large area of level or gently rolling prairie. The well appointed grounds of the "Grand Prairie joint-stock Agricultural Society" are located adjoining the village. At the time of my visit, the County Fair was in progress. The live stock, especially swine and cattle, and other products, would compare favorably with those exhibited at any county fair in the State. Comfortable residences, neatly kept farms, were significant and characteristic of this vicinity. From Dr. Peter's report (Owen's Geol. Ind., 1859,) I copy the following tabulated analysis of soils from Wagner's Grove, Sec. 14, T. 23, R. 7.

	No. 19.—Virgin soil in Grove.	No. 20.—Prairie soil in old field.	No. 21.—Bottom prairie soil.	No. 22.—Subsoil at 1 foot.	No. 23.—Subsoil at 2 feet.	No. 24.—Subsoil at 3 feet.
Organic and volatile matters	1.266	0.983	1.127	0.800	0.500	0.550
Alumina and Oxides of Iron, Manganese and Phosphates	.603	.323	.090	.247	.073	.130
Carbonate of lime	1.793	1.477	1.610	.641	.410	1.127
Magnesia	.380	.383	.321	.144	.100	.227
Sulphuric acid	.079	.113	.107	.104	.129	.068
Potash	.064	.147	.109	.145	.177	.060
Soda	.122	.182	.209	.187	.067	.161
Silica	.380	.420	.337	.330	.247	.347
Loss	....	....	.307	....	.227	....
Extract, dried at 212° F., grains	4.687	3.978	4.217	2.598	1.900	2.670

The *chemical composition* of these soils, dried at 440° F., is represented as follows:

	No. 19.—Virgin soil, grove near prairie.	No. 20.—Prairie soil, rising ground, old field	No. 21.—Prairie soil, bottom.	No. 22.—Prairie sub-soil at 1 foot.	No. 23.—Prairie sub-soil at 2 feet.	No. 24.—Prairie sub-soil at 3 feet.
Organic and volatile matters	8.286	5.473	8.851	2.805	2.654	2.931
Alumina	2.010	2.610	4.335	1.810	2.460	2.965
Oxide of iron	3.365	2.740	3.315	2.150	3.765	4.540
Carbonate of lime	.945	.645	1.545	.270	.395	.895
Magnesia	.753	.795	.878	.519	.599	.901
Brown oxide of manganese	.215	.115	.190	.090	.215	.190
Phosphoric acid	.255	.198	.237	.194	.161	.214
Sulphuric acid	.153	.100	.127	.062	.084	.050
Potash	.256	.125	.300	.235	.272	.360
Soda	.038	....	.068	.041	.036	.056
Sand and insoluble silicates	82.615	86.565	80.515	91.490	88.065	86.066
Loss	1.109	.634	....	.334	1.294	.812
Total	100.000	100.000	100.388	100.000	100.000	100.000
Moisture expelled at 400° F	7.375	5.000	7.075	2.850	2.975	4.475

I may quote Professor Owen's conclusions:—

"The essential mineral elements of vegetable nourishment being abundant, with plenty of organic matter to aid in their solution, these soils ought to be quite productive."

Specimens of bog iron ore are found near Pine village. The quality is good. Extensive beds are not known.

At Rainsville good exposures of the conglomerate sandstone occur. Thence south this formation underlies or forms all the bluffs on the east side of the stream to a point below the mouth of Fall creek. Generally it is seen also in the bluffs on the west side; the strata dipping to W. or S. S. W. The central trend of the creek valley follows the line of strike. The disintegrating material at the horizon of coal

A, seems to have been the initial inducement that gave direction to the creek.

Outcrops of colored conglomerates are noted near the mouth of Mud Pine. Jacob Beisel works a quarry N. E. qr. Sec. 29, T. 23, R. 8. The product was used for piers at the bridge higher up the stream. The stone lies nearly horizontal. It is striped with diagonal red lines traversing the strata, at angles of from 10° to 30°, called false bedding. These highly colored stones indicate material covered soon after deposit, buried before the surf and waves had time to purify the material by washing, (Dawson's Earth and Man). The diagonals here, at Milford and at Williamsport face to W. S. W., and for their origin demand a sedimentary stream from E. N. E., and a broad, deep, wave-tossed sea* to W. S. W.

On Beisels' land, one-fourth mile to the west, is a remarkable quarry of sandrock, showing an outcrop of 15 feet, in beds one to two feet thick. This stone may be broken or split to blocks or slabs of any desired size. Weathered exposures present a grayish white color; but when being dressed fresh from the quarry, every stroke of pick or chisel develops a faint show of vermilion or carmine. The sensitiveness to blow or cut has given this stratum the name of "Bleeding Stone." The color arises from thread-like diagonals of oxide of iron. The product of this quarry bears an excellent reputation for endurance. It forms the piers at Rainsville bridge. On the same tract a bed of impure caking coal occurs. Only weathered fragments were visible.

At Jno. T. Briscoe's bank, worked by W. R. Hardesty, the following section was taken, extending along Mud Pine across the dip, viz:

SECTION AT BRISCOE'S COAL MINE.

S. E. Quarter, N. W. Quarter, Sec. 29, *T.* 23, *R.* 8.

Drift and soil.........	20 ft. 00 in. to 10 ft. 00 in.
Grindstone grits and yellow sandstone...	10 ft. 00 in.

*For further discussion, see authority cited.

Slate and iron stones.	3 ft. 00 in. to	1 ft. 2 in.
COAL M—impure-caking..............	2 ft. 00 in. to	1 ft. 4 in.
Fire clay...............		3 ft. 00 in.
Covered......	5 ft. 00 in. to	1 ft. 00 in.
Soapstone and argillaceous sandstone..		6 ft. 00 in.
Soapstone; Fernbed, containing leaves of *Lepidodendra*, *Cardiocarpum ingens*, *Cordaites borassifolia*, *Neuropteris rarinervis*, *N. hirsuta*, *Odontopteris* (Sp?), *Pecopteris arborescens*, P. (Sp), *Alethopteris Serlii*, A. *lonchitica* *Sphenophyllum Schlotheimi*, *Asterophyllites equi-setiformis*, and *Annulariæ*.................	1 ft. 00 in. to	2 ft. 00 in.
COAL L.		
Laminated coal good	00 ft. 4 in.	2 ft. 6 in.
Choice blacksmith coal..................	1 ft. 6 in.	
Laminated coal........	00 ft. 6 in.	
Black and gray slate, with leaves of *Sigillaria*...............		1 ft. 6 in.
Impure, irregular coal, (K?)...........	10 in. to	1 ft. 4 in.
Fire clay, to water...		3 ft. 6 in.
		43 ft. 4 in.

At outcrops of underlying strata in the bed of the creek, no showing of coal or accompanying strata were seen lower than the bottom of this section, and the existence of a workable bed below, while possible, is highly improbable.

Briscoe's bank yields a compact, clean, lustrous semi-caking coal, which burns to a white ash. Locally it is esteemed as a steam, household or smith coal. It is well suited for locomotive or rolling mill purposes, and with the addition of less than one-half coke may be used for smelting iron. The "fern bed" presents an attractive variety of well preserved plants, characteristic of the roof shales of Coal L.

Outcrops of coal about 2 feet thick are reported on adjoining lands, S. W. ¼ N. E. ¼ Sec. 29, T. 23, R. 8. At the mine the worked seam dips N. W. at about 60 feet per mile. This is probably only a local wave. Ascending the stream, the upper coal is scattered in pockets at the crest of *rolls* or *waves*, from 4 to 7 feet high, and with a space of from seventy to one hundred and fifty feet between. A sectional cut would be necessary to convey a correct idea of this interesting feature. I can only account for this phenomenon, by referring it to a rush and return of successive tidal waves "boring" a narrow arm of the ancient ocean.

Spaces between the pockets diminish as we proceed north. On John Steeley's land, N. E. ¼ Sec. 19, T. 23, R. 8, an outcrop coal, heretofore reported as four feet thick, occurs.

A Lafayette mining company commenced on this, and drove a horizontal entry 126 feet on the seam in a W. N. W. course, which resulted in demonstrating that the features so plainly seen in the outcrop, continued under the hill. Dr. James C. Deming informs me that the entry crossed five of these wave lines nearly at right angles. He found the rolls from 6 to 12 feet apart. The "pockets" of coal were flattened cylinders or elongated trapeziums, crushed when in a plastic state, from one to three feet thick, and connected by a parting or thread of carbonaceous matter. The coal was mostly impure and worthless; although some bright and lustrous lumps were found. This disastrous experiment

was abandoned. Heavy bands of siliceous ores of iron were noticed along the bed of Mud Pine, between Steeley's and Briscoe's, containing *Spirifera*, *Producta*, and a few other coal measure fossils.

At "Cedar Bluff," on Pine creek, the ancient conglomerate bluff faced west, and sloped in that direction with an incline of from three hundred to five hundred feet per mile. Against this slope, at the beginning of the coal epoch, a grand bed of bituminous shales and iron ore was deposited the confusedly mixed materials of Coal K. and accompanying strata. North and south from the bluff, the conglomerate is well exhibited, but here, a sudden westing of the stream has cut away the sandrock, exposing iron ores and shales as follows, viz:

SECTION AT CEDAR BLUFF, N. W. QR., SEC. 9, T. 22, R. 8.

Boulder and fluviatile drift 40 to......	60 ft.	00 in.
Shale..	12 ft.	00 in.
Band, averaging 7 in. iron ore..........	2 ft.	6 in.
Blue and black carbonaceous shale.....	11 ft.	00 in.
Banded nodules of iron ore ranging from 10 lbs. to a ton, av. 8 in. thick		.8 in.
Blue shale with iron nodules 4 to......	8 ft.	00 in.
Conglomerate sandstone 0 to...........	25 ft.	00 in.
	119 ft.	2 in.

These bands and masses of iron are in sufficient quantity and quality to justify the belief that with facilities for transportation, they will pay for mining. On this horizon, iron ore may be found, hence north a short distance, and south as far as Dix's mills, with a probability of many paying deposits. One kidney-shaped mass of ore, eight feet long, three feet wide and one foot thick, would weigh more than a ton, while hundreds were seen weighing from one hundred to five hundred pounds. The quality is good. For analysis I refer to the Chemist's report.

Descending Pine creek, we find the eastern bank presents a bold front of precipitous or overhanging conglomerate, from sixty to one hundred feet high, capped by the laminated or quartzose beds accompanying the "place" of coal A., with massive or heavy bedded strata below. Beautiful pine trees shade the crest of the bluff. Irish and Virginia junipers are found on the slopes and bottoms. The dark shady valleys are crowded with ferns, and at Brier's stone quarry N. E. qr. N. E. qr. Sec. 16, T. 22, R. 8, the rocks wére covered with climbing ferns (*Lygodium*,) whose hastate fronds are armed with long hooked spikelets which reach forward, seize upon some object and then take root.

The quarries in this vicinity furnish an excellent quality of stone; brown, gray and snow white. It may be obtained in massive blocks, and split or broken in any direction desired; soft from the quarry, it hardens on exposure to the air.

On David M. Kelley's land, S. W. qr. N. W. qr., Sec. 15, T. 22, R. 8, is a quarry long worked for local use, presenting a bare outcrop of sixty feet; principally white freestone, and combines with purity of color all the good qualities of this stone. Sills and lintels from this quarry in the house of Mr. Andrew Brier, after 18 years' exposure, show chisel marks and corners as sharp as if just from the hands of the workmen. The rocks of the quarry are covered with mosses and lichens further indicating their capacity to resist atmospheric action.

On Hogue's land N. E. qr. S. E. qr. Sec. 16, T 22, R. 8, is a bed of kidney and banded ore carrying from thirty to fifty per cent of iron. The bands are of great thickness, and the concretions massive. The quantity indicated by the wash of the branch is large. Bog iron ore, probably in limited quantity, is reported on the land of Levi R. Van Reed, Sec. 31, T. 23, R. 8.

Deposits of washed sand and gravel found at Walnut Grove, and on the ridges which traverse the northwestern and western parts of the county, have been variously referred, by different authorities, to moraines of glaciers

or icebergs or the shore lines of an old lake. They are of fluviatile origin, and date back to the infancy of our water courses, then having no deep or constant channel.

John Thomas works by stripping coal M, N. W. qr. Sec. 20, T. 22, R. 8, near where the State road crosses Fall creek. A heavy band of lean silicious iron ore, with fossils accompanies the roof shales. The pit was filled and specimens of coal were not obtained.

Matthias Luppoldt works coal L. at the place formerly known as the "Keister" bank N. W. qr. Sec. 21, T. 22, R. 8. Five entries have been driven on this seam in the southern bluff of Fall creek. In the bed of the creek coal K. has been found with its limestone roof, and on the hill side outcrops of M. are seen.

SECTION AT LUPPOLDT'S BANK.

Slope		
Yellow sandstone		8 ft. 00 in.
Hard ferruginous argillite and iron stones, 2 ft. to		4 ft. 00 in.
Black sheety slate, 6 in. to		1 ft. 4 in.
Coal M., caking		1 ft. 10 in.
Fire clay		3 ft. 00 in.
Soapstone and shaly S. S		10 ft. 00 in.
Soapstone and sandy shale with ferns and coal plants		8 ft. 00 in.
Coal L, *worked.*		
Laminated coal	0 ft. 10 in.	
Slaty coal	4 in.	
Block coal	2 ft. 4 in.	
	—————4½ ft. to	3 ft. 6 in.
Fire clay		4 ft. 00 in.
Blue shale, 6 ft. to		8 ft. 00 in.
Limestone or calcareous shale		2 ft. 6 in.
Black slate		10 in.
Coal K., under water, reported		3 ft. 4 in.
Fire clay—not known.		
		58 ft. 4 in.

Coal L dips to southwest one inch per foot. Coal K dips more rapidly.

The product of this mine bears an excellent reputation. It mines in blocks or slabs, has the heavy ring and dull lustre of block coal, and burns with little flame, to a white ash, without clinker. The seam ranges in thickness from 3 to 4½ feet, averaging three and a half feet. I add analysis from R. Owen's report 1860:

Analysis of Keister's Coal.

Volatile matter,	42.00	Gas,	40.00
		Water,	2.00
Coke,	58.00	Carbon,	51.05
		Ash,	6.05
	100.00		100.00

This indicates a strong coal, rich in carbon. Amount mined in 1871, was 16,000 bushels; in 1872, 12,000 bushels. A test bore near the joined corners of sections 20, 21, 28, 29, found coals M. and L.; the latter, three and a half feet thick.

Andrew Fink works coal K. by three openings on W. ½ N. E. ¼ Sec. 21, T. 22, R. 8, with the following exposure:

SECTION AT A. FINK'S BANK.

Slope		
Bit. limestone with fossils		2 ft. 00 in.
Calcareous shale, with fossils		0 ft. 09 in.
Black slate, with *Lingula*, etc		1 ft. 02 in.
COAL K.		
Rough coal	0 ft. 06 in.	3 ft. 02 in.
Semi-block coal	1 ft. 04 in.	
Block coal	1 ft. 02 in.	
Soft shale	0 ft. 02 in.	
Fire clay		4 ft. 00 in.
		11 ft. 01 in.

This bank was but partially opened. It promises good coal.

A. C. Jarvis has one opening on N. E. ¼ N. E. ¼ of Sec. 21, T. 22 R. 8. His bank gives the following exhibit, viz

JARVIS' COAL SECTION.

Slope..............			
Black slate roof...........................			4 ft. 00 in.
Coal K.			
Laminated pyritous coal	0 ft. 06 in.		3 ft. 08 in.
Semi-block coal.........	1 ft. 10 in.		
Block coal.................	1 ft. 02 in.		
Soft slaty coal............	0 ft. 02 in.		
Fire clay....................................			4 ft. 00 in.
			11 ft. 08 in.

This contains some sulphur, but presents a good appearance, and is largely *good block coal.*

At Dix's mill, N. W. ¼ Sec. 22, T. 22, R. 8, a spur of conglomerate sandstone, once crossed the present channel of Pine creek. The stream has cut its way through this obstruction, exposing a triangular cross section at the west abutment of the present mill dam. Wedges of sandstone are thrown in against the sides of this spur, rounding over the sharp apex of the ridge, followed by strata of rock, iron ore, shale, and carbonaceous matter which arch over this hill of the ancient world.

In the bluffs of Pine, near the mouth of Fall creek, are many good beds of nodular and banded iron ore. At several points, bands outcrop, having a thickness of seven to nine inches. The nodules are often massive. One hundred tons weight might be "picked up" from surface washings. The quality is from fair to *first rate.*

Half a mile below the mouth of Fall creek, (center of Sec. 22, T. 22, R. 8), the bluffs of Pine creek contain a heavy deposit of black and dark colored carbonaceous shales, with a large amount of iron ore. The following section was taken, viz:

REPTILIAN SECTION ON PINE CREEK.

Slope..............................		
Black carbonaceous shale.....		3 ft. 06 in.
Bit. and Argil. limestone, with *Nautilus decoratus* and *Orthocerata*..............		2 ft. 03 in.
Blue and black shale, with banded, nodular and concretionary masses of iron ore, (place of Coal K)......		23 ft. 00 in.
Thinly laminated quartzose sandstone, with casts of sun cracks and reptilian tracks on the under side, and *fucoides* and *Chondrites* on the upper side of the laminæ..............................	1 ft. to	2 ft. 04 in.
Flaggy sandrock...............	3 ft. to	7 ft. 00 in.
Black Carb. shale, (place of Coal A.)......................	2 ft. to	3 ft. 00 in.
Quartzose sandstone...........		08 in.
Dark shale.......................		3 ft. 04 in.
Laminated sandstone..........		2 ft. 00 in.
Irregularly bedded sandstone		14 ft. 00 in.
		— —
		61 ft. 01 in.

The reptilian tracks which give importance to this section, are from the thinly laminated sandstone under the black shale, which contains the large iron nodules. A description and figure is published in this volume by Prof. Cox, to which I refer for particulars. One fragment exhibited four tracks, each having five toes. Two other tracks, somewhat indistinct, seem to have been made by the same animal. A smaller fragment showed a single, similar track.

On James Schoonover's land, leased by the Lafayette Mining Company, W. hf. S. E. qr. of Sec. 21, T. 22, R. 8 W., coal K is worked for the company under the direction

of Mr. Spurrier, to whom I am indebted for information. The entry was full of water and not seen.

SECTION AT SCHOONOVER'S BANK.

Slope		30 ft. 00 in.
Calcareous shale or limestone		2 ft. 00 in.
Black slate roof		2 ft. 6 in.
Coal K.		
Choice cooking coal	0 ft. 10 in.	
Semi-block—some pyrite	1 ft. 7 in.	
Block coal	10 in.	
Soft black slate	3 in.	
		3 ft. 6 in.
Fire clay		3 ft. 6 in.
		41 ft. 6 in.

The specimens obtained for analysis had been exposed on the surface for a year. The seam locally dips an inch in ten feet to northwest. At this bank, as at those of Fink and Jarvis, the soft coaly shale at the bottom furnishes easy material on which to "bear in."

Three other bores were put down to the *horizon level* at which K is found at the mine, without results. If allowance had been made for the dip, the necessity of boring a few feet deeper, would have been obvious.

A shaft was sunk on the same farm to a depth of one hundred and twenty-five feet. Judging from the *ejecta* around the top of the shaft, the horizon of coal K was passed at a point where excavation made by the bowlder drift had eroded the coal. The shaft terminated about the place of Coal A.

Contiguity of outcrops indicate a persistent seam of coal in a line from east to west of more than two miles. The quality is well suited for smelting iron. With facilities for transportation, anticipated by the proposed Lebanon and Michigan City Railroad, which passes through the heart of the Warren County coal fields, we may expect a full development of these valuable coals.

16

ECONOMICAL GEOLOGY.

Agriculture.

It is believed that a good soil is the surest basis of a nation's comfort and prosperity. The people of this country ought to be comfortable, prosperous and happy. Nature has endowed them with a grand area of prairie, terrace level and bottoms, proportioned as five to one with the broken or hilly lands, which is covered with a black, deep, rich soil, producing large crops of corn and grass—the main reliance of profitable husbandry. No manure is used or required. An occasional crop of clover will restore and maintain the original fertility. The Kent and Tomlinson farms, among the earliest improved, are still noted for their heavy yield of corn and hay, although continuously cropped for nearly half a century. Bluegrass (*poa pratensis*) is indigenous; large pastures were found adjoining the Indian villages, which furnished winter feed for the horses of the tribe; and at an early day a wide belt of this grass marked the Indian trace by which Harrison's army marched to Tippecanoe. The introduced grasses thrive well. Other crops, as oats, rye, wheat and potatoes, are from fair to good, and may be equalled; but in the highly paying products, characteristic of this region, Warren county hardly admits of a rival.

The peculiar configuration of the Wabash and its affluents has moulded the general surface of this country into a great plane, sloping to the southeast. Thus an unusual preponderance of surface is presented to the warm rays of sunrise. As is well known, this is equal in effect to a much prolonged summer, and insures remarkable maturity and richness in the products of the garden, orchard and field.

Much attention has been paid to improved breeds of live stock. Success in this department was noted at the fair ground exposition; but more significant was the numerous herds of fat bullocks, luxuriating upon a noble sward of bluegrass. Timber for home use is in good supply, although not abundant. Hedges of osage orange are cultivated, and

it is believed will make a secure fence against horses, sheep and cattle. When necessary, local laws may require the owner to restrain his swine from trespassing on the public, and thus reduce the cost of fences one-half.

The deep, oozy loam of the grand prairie invites underdraining. Experience demonstrates that farmers can not make a better investment than the purchase and use of draining tiles. Health and comfort suggest that the first experiment by every land holder should be the thorough drainage of the grounds about the house, the garden and the barn.

CLAY.

Clay of good quality for bricks is found in nearly all parts of the county. The under clays of the coal seams are well developed, and are even of greater value than the coals. These afford first-class material for pottery, terra-cotta works and tile making. The supply is unlimited.

WATER POWER.

Several mills on Pine creek and Kickapoo, are driven by water, which is the cheapest possible power. The surplus water of these streams and flood water of Redwood may be profitably devoted to the sawing of stone. Several good mills on the line of the railway are propelled by steam.

WINDMILLS.

Water for farm and household use, is cheaply supplied by the use of self-regulating windmills. The satisfaction with which these engines are regarded by the grazers, is an indication of their merit. Not less than twenty were seen in successful operation.

ROAD MATERIALS.

Good roads, passable at *all* seasons, are necessary for the full enjoyment of civilization and social life. Experience shows that the best material known to road masters, is the gravel washed from the boulder drift. This county is richly supplied. Immense beds are found along the river and creek bluffs.

METALS.

Virgin copper and gold are found in small quantities. These metals, with small nuggets of galena, were imported from the north with the rocks of the boulder drift.

Tales of French Priests, locate silver and lead mines on Little Pine creek. No indications were seen, supporting such stories, or even allowing a possibility of their truth. Kidney and banded ores of iron, of good quality, are seen along the west side of Pine creek. The quantity will justify careful exploration and trial. These beds of calcareous and clay iron stones, with neighboring beds of block coal, invite the examination of iron masters.

STONE.

It will be seen from the foregoing pages that this county has extensive beds of quarry sandstone. Those of the conglomerate are especially worthy of mention. Blocks of any convenient size may be obtained, while the bright and vivid colors of the red and striped strata afford opportunity for ornament and contrast. The thinly bedded layers of Chester sandstone are often of great homogeneousness. Those on Redwood have been sawed. Specimens from the quarries east of town may be seen in the old buildings at Williamsport, erected for the county offices.

COAL.

The coals of this county are of good quality. Sufficient explorations have not been made to fully determine the quantity, yet enough to show a considerable deposit. It may be proper here to say, for the information of the people, that coal seams are rarely continuous over large areas; "horsebacks" occur, and barren places intervene in the best regulated coal fields. These interruptions grow in frequency and intensity as we approach the margin of the basin, where, owing to its physical structure, block coal is only found to occur. Such is the case at Brazil; such, too, in the Mahoning valley, where eight-tenths of the basin is

without coal. We may expect that this basin is governed by the law which is known to rule in other fields, and that basins or pools of coal will be found isolated and surrounded by much barren territory.

Again, while we see that the coal measures extend indefinitely west and southwest from the conglomerate rim of the basin, yet geologists have noted that the surface configuration is largely moulded by the underlying rocks; and we may infer that under the dividing ridge, which passes from the north in a south-south-westerly direction, through the western part of the county, on a hidden ridge of stone, makes the coal too thin to work along much of its extent. Hence, in attempting to guess at the extent of a drift covered and but slightly developed coal field, we can only say that its probable area is a basin from naught to three miles wide, commencing at Briscoe's bank, T. 23, R. 8, and extending, more or less continuously, and curving from this, westerly to Fall creek, thence south and east, by Coal branch and the valley of Possum run, to the Wabash. The same reasoning would indicate possible beds of coal along the State line in the north part of township 21, and the south part of township 22, both of range 8.

An abundant supply for home use has already been discovered; if the deductions here made are found to be true, a field of such an extent will allow a liberal margin for exportation.

RAILWAY FACILITIES.

The county is traversed from southwest to northeast by the Toledo and St. Louis road (T., W. & W. Ry.) The Indiana, N. & S. road, offers competing rates from Attica and the Indiana division of the C., D. & V. Ry. opens a route by that line to Chicago and the northwest. Citizens of the county feel that their agricultural and mineral products demand a direct route to the lake ports. They have organized a company and surveyed an eminently feasible route from West Lebanon to the north line of the county, in the direction of Michigan City. This road would traverse

a first class farming region, and at the same time, the richest and best developed mineral beds of the county.

ANTIQUITIES.

The terrace prairies were the favorite home of our most ancient American people. "Mound prairie," in the extreme southeastern part of the county, takes its name from clusters of mounds on its borders. Two large mounds were seen on the terrace bluff north of Kickapoo. Stone implements of good workmanship are common. A stone drill, in my cabinet, found at Independence, is made of hard horn-blend granite. It is pointed with two cutting edges, showing that the ancient artificers in stone, invented the mechanical contrivance used by his modern brother in piercing the hardest metals.

THANKS.

Thanks are returned to the citizens of Warren county generally for courteous assistance. Acknowledgements are due to the County Commissioners—Messrs. A. Brier, Sam'l Frame, and Zimri Atkinson—who appropriated funds to defray the expenses of this survey, and to the following persons for special favors: Wm. Moffitt, Hon. W. P. Rhodes, Dr. Boyer, L. Van Reed, J. Steeley, J. Briscoe, Rev. Geo. Davis, L. Bittinger, J. A. Johnston, O. Munson, Dr. J. C. Deming, Dr. Fleming, the Lebanon Mining Co., W. Hasty, Perrin Kent, and the citizens at Marshfield.

COLLETTOSAURUS INDIANAENSIS, NOV. SP.
(natural size.)

COLLETTOSARUS INDIANAENSIS.—*Cox.*

Mr. John Collett, while prosecuting the survey of Warren county, this fall, found in the carboniferous strata near the base of the coal measures, fossil foot prints of an air breathing reptile, to which I have given the name of *Collettosaurus Indianaensis.*

The tracks are the reverse casts which stand up in bold relief, and the entire face of the slab containing them exhibits a minute copy of the sun cracked surface of the plastic mud upon which they were impressed.

A natural sized figure is given of a portion of the slab; see opposite page.

Faint impressions of tracks on other portions not figured, may be readily discerned.

Two pairs of tracks of hind and fore feet are quite distinct, and from their position seem to indicate that the animal was allied to the *Batrachians,* and progressed like the frog, by jumps, while on the other hand the five digits on either foot relate it to the *Salamanders.*

Reptilian remains found in a similar geological horizon at Morris, in Grundy county, Illinois, are described in the Geological Report of Illinois, volume 2, by Prof. Edward D. Cope and referred by that distinguished comparative anatomist to the *Batrachians;* The head, vertebræ and a portion of the leg bones and phalanges are well preserved in Cope.s *Amphibamus grandiceps* of Grundy county, and enabled him to recognize the blending of *Batrachian, Lacertian* and *Salamandrine* characters. While the foot-prints on the slab from Warren county afford no such guide of themselves, we may reasonably infer from the reptiles being close neighbors and correlated in time that while the five digits on the hind and fore feet are *Salamandrine* characters, the position of the tracks with reference to each other ally it to the *Batrachians.*

The impressions of the feet are in very great relief.

Each foot contains five toes, one of which, on the hind foot, measures three quarters of an inch in length; the spread is one and a quarter inches long and one inch broad, the space between the centres of the hind feet is three inches, between the fore feet one and a half inches. From the hind foot to the fore foot of each leg the space is four inches.

The character of the stratum containing these foot print slabs give assurance, as remarked by Prof. Collett, in his notes accompanying the specimen, that the entire deposit was found along a low beach subject to periodical overflows. The mud deposit, now shale, over which the reptile travelled, probably by jumps, as the position of the tracks seem to indicate, must have been quite soft, as the casts show a deep impression and remained long enough exposed to the influence of the air and sun to partially dry and become checkered with shrinkage cracks. The subsequent overflow covered it with a thin deposit of fine, bluish gray, siliceous mud which not only took a faithful impression of the tracks but, likewise, copied the sun-cracks. Asmall ridge on the upper part of the figured portion of the slab represents a small crack, while on a portion not figured there is an elevation, made in this way, one inch wide and five eighths high.

It is to be hoped that future research will develope other specimens that will enable us to determine more fully the character of these remarkable reptiles.

ANALYSES OF COALS;

From Warren county, Indiana, collected by Prof. Collett and here described in the order of their arrangement in the tables of analyses at the end of this report:

JOHN BRIGG'S COAL K;

Formerly known as the Steely farm, Sec. 11, T. 20, R. 9. Seam twenty inches thick; color, black; thin laminæ with carbonaceous partings; variety, block coal.

Specific gravity, 1.212. One cubic foot weighs 75.75 lbs.

Coke, - -	50.50	Ash, flesh, - -	2.00
		Fixed carbon, - -	48.50
Volatile matter,	49.50	Water, - - -	4.75
		Gas, - - - -	44.75
	100.00		100.00

The coke is slightly swollen, laminate and vitreous. This is a good coal and free from earthy impurities.

J. T. BRISCOE'S COAL L;

Sec. 29, T. 23, R. 8. Two feet four inches thick. Top part, brilliant black coal, with soft carbonaceous matter between the laminæ; variety, semi-caking coal.

Upper part:

Specific gravity, 1.223. One cubic foot weighs 76.44 lbs.

Coke, - -	64.50	Ash, gray, - -	7.00
		Fixed carbon, - -	57.50
Volatile matter, -	35.50	Water, - - -	3.50
		Gas, - - - -	32.00
	100.00		100.00

Coke puffed, brilliant and laminate.

Middle part:

One foot four inches thick, glossy black.

Specific gravity, 1.267. One cubic foot weighs 79.18 lbs.

Coke,	62.70	Ash, blue,	8.00
		Fixed carbon,	54.70
Volatile matter,	37.30	Water,	3.50
		Gas,	33.80
	100.00		100.00

Coke not puffed, laminate and vitreous.

Lower part:

Somewhat sulphury.

Specific gravity, 1.350. One cubic foot weighs 84.37 lbs.

Coke,	68.25	Ash, blue,	16.00
		Fixed carbon,	52.25
Volatile matter,	31.75	Water,	3.00
		Gas,	28.75
	100.00		100.00

Coke not puffed, laminate and vitreous.

Taken altogether this is a good and popular coal for steam and house use.

R. W. CLAYPOOL'S COAL L;

Sec. 9, T. 20, R. 9, 2 ft. 6 in. thick.

Upper part:

One foot, brilliant black.

Specific gravity, 1.246. One cubic foot weighs 77.87 lbs.

Coke,	58.50	Ash, red,	10.00
		Fixed carborn,	48.50
Volatile matter,	41.50	Water	3.00
		Gas,	38.50
	100.00		100.00

Coke puffed, vitreous and amorphous.

Middle part:

Ten inches, dull black, mineral charcoal partings.

Specific gravity, 1.214. One cubic foot weighs 75.87 lbs.

Coke, - - -	58.00	Ash, white, - - -	2.50
		Fixed carbon, - -	55.50
Volatile matter,	42.00	Water, - - -	4.00
		Gas, - - -	38.00
	100.00		100.00

Coke puffed, amorphous and brilliant.

Lower part:

One ft. 2 in., dull black, laminated structure, contains a little pyrites.

Specific gravity, 1.205. One cubic foot weighs 75.31 lbs.

Coke, - -	63.00	Ash, brown, - -	8.50
		Fixed carbon, - -	54.50
Volatile matter,	37.00	Water, - - -	3.00
		Gas, - - -	34.00
	100.00		100.00

Coke much puffed, vitreous, amorphous.

This is a very good quality of caking coal and meets with a ready market.

R. W. CLAYPOOL'S COAL M ;

Sec. 9, T. 20, R. 9. Upper seam, dull black, 1 ft. thick variety, caking coal.

Coke, - -	51.50	Ash, brown, - -	3.50
		Fixed carbon, - -	48.00
Volatile matter,	48.50	Water, - - -	3.50
		Gas, - - - -	45.00
	100.00		100.00

Coke puffed, lusterless.

GOODRICK'S COAL M.

Sec. 2, T. 20, R. 9. Upper seam, dull black caking coal, 1 ft. 6 in.

Specific gravity, 1.343. One cubic foot weighs 83.93 lbs.

Coke, - -	54.50	Ash, red, - - -	9.50
		Fixed carbon, - -	45.00
Volatile matter,	45.50	Water, - - -	6.00
		Gas, - - -	39.50
	100.00		100.00

Coke brilliant, laminate, not puffed.

GOODRICK'S COAL L.

Sec. 2, T. 20, R. 9; lower seam, glossy black, brittle, caking coal; 3 ft. thick.

Upper part:

Eight inches.

Specific gravity, 1.304. One cubic foot weighs 81.50 lbs.

Coke, - -	55.00	Ash, purple, - -	8.50
		Fixed carbon, -	46.50
Volatile matter,	45.00	Water, - - -	3.00
		Gas, - - -	42.00
	100.00		100.00

Coke slightly puffed, laminate, lusterless.

Lower part:

Fourteen inches, jet black and brittle.

Specific gravity, 1.262. One cubic foot weighs 98.87 lbs.

Coke, - -	50.00	Ash, flesh, - -	4.50
		Fixed carbon, -	- 46.00
Volatile matter,	49.50	Water, - - -	3.00
		Gas, - - -	46.50
	100.00		100.00

Coke puffed, vitreous, amorphous.

This is an excellent coal for steam and domestic uses.

HOOPER & BARRINGER'S COAL L.

Sec. 8, T. 20, R. 9; dull, black, laminated block coal, with charcoal partings; worked from a shaft; seam 2 ft. 8 in. thick.

Upper part:

Ten inches.

Specific gravity, 1.238. One cubic foot weighs 77.37 lbs.

Coke, - -	61.50	Ash, white, - -	2.50
		Fixed carbon, - -	59.00
Volatile matter,	38.50	Water - - -	4.00
		Gas, - - -	34.50
	100.00		100.00

Coke, laminate, vitreous, not swollen.

Lower part:

Twenty-two inches, mined in large blocks.

Specific gravity, 1.236. One cubic foot weighs 77.25 lbs.

Coke, - -	58.50	Ash, white, - -	2.50
		Fixed carbon, - -	56.00
Volatile matter,	41.50	Water, - - -	6.50
		Gas, - - -	35.00
	100.00		100.00

Coke, brilliant, laminate, not swollen.

This is an excellent quality of block coal.

HAROLD & CO'S COAL L.

Sec. 9, T. 20, R. 9. Brilliant black caking coal, 2 ft. 8 in. thick.

Upper part:

One foot.

Specific gravity 1.282. One cubic foot weighs 80.15 lbs.

Coke, - -	60.50	Ash, red, - -	6.50
		Fixed carbon, - -	54.00
Volatile matter,	39.50	Water, - - -	3.50
		Gas, - - - -	36.00
	100.00		100,00

Coke not puffed, laminate, vitreous.

Middle part:

Six inches, good gas coal.

Specific gravity, 1.290. One cubic foot weighs 80.62 lbs.

Coke,	57.00	Ash, white,	7.50
		Fixed carbon,	49.50
Volatile matter,	43.00	Water,	4.50
		Gas,	38.50
	100.00		100.00

Coke puffed, amorphous, vitreous.

Lower part:

One foot two inches dull black, laminated, with soft carbon partings.

Specific gravity, 1.252. One cubic foot weighs 78.25 lbs.

Coke,	59.50	Ash, white,	3.50
		Fixed carbon,	56.00
Volatile matter,	40.50	Water,	9.50
		Gas,	31.00
	100.00		100.00

Coke, slightly swollen, laminate, vitreous.

This coal looks well and shows no sulphur bands.

A. C. JARVIS' COAL K.

Sec. 22, T. 23, R. 8. Block coal, 3 ft. 9 in. thick.

Upper part:

Six inches.

Specific gravity, 1.243. One cubic foot weighs 77.68 lbs.

Coke,	57.00	Ash, red,	6.50
		Fixed carbon,	50.50
Volatile matter,	43.00	Water,	5.00
		Gas,	38.00
	100.00		100.00

Coke, vitreous, slightly puffed, laminate.

Middle part:

One foot ten inches; dull, black, laminated structure, soft carbon partings.

Specific gravity, 1.251. One cubic foot weighs 78.18 lbs.

Coke, - -	56.50	Ash, white, - -	3.00
		Fixed carbon, - -	53.50
Volatile matter,	43.50	Water, - - -	2.75
		Gas, - - - -	40.75
	100.00		100.00

Coke slightly puffed, laminate, vitreous.

Lower part:

One foot two inches; laminated structure.

Specific gravity, 1.348. One cubic foot weighs 84.25 lbs.

Coke, - -	63.50	Ash, white, - -	12.00
		Fixed carbon, - -	51.50
Volatile matter,	36.50	Water, - - -	3.50
		Gas, - - - -	33.00
	100.00		100.00

Coke unchanged, laminate, lusterless.

The middle part of this seam is an excellent quality of block coal; the upper and lower parts are of fair quality.

LUPPOLDT'S COAL L.

Sec. 22. T. 23, R. 8. Semi-block, 3 ft. 6 in. thick.

Upper part:

One foot dull black, laminated structure.

Specific gravity, 1.222. One cubic foot weighs 76.37 lbs.

Coke, - -	58.50	Ash, dark red, - -	9.50
		Fixed carbon, -	49.00
Volatile matter,	41.50	Water, - - -	4.50
		Gas, - - -	37.00
	100.00		100.00

Coke slightly swollen, brilliant, laminate.

Middle part:

Four inches, laminated, with soft carbon partings.

Specific gravity, 1.254. One cubic foot weighs 78.37 lbs.

Coke, - -	61.50	Ash, red, - - -	9.00
		Fixed carbon, -	52.50
Volatile matter,	38.50	Water, - - -	5.00
		Gas, - - -	33.50
	100.00		100.00

Coke not swollen, laminate, lusterless.

Lower part:

Two feet, two inches; clean, pure coal.

Specific gravity, 1.256. One cubic foot weighs 78.50 lbs.

Coke, - -	61.50	Ash, white, - -	4.50
		Fixed carbon, - -	57.00
Volatile matter,	38.50	Water, - - -	3.00
		Gas, - - - -	35.50
	100.00		100.00

Coke laminate, lusterless, unchanged.

This seam, taken altogether, furnishes an excellent quality of coal.

SCHOONOVER'S COAL K.

Sec. 21, T. 22, R. 8; dull black, laminated block coal with soft carbon partings, 3 ft. 6 in. thick.

Upper part:

Ten inches.

Specific gravity, 1.284. One cubic foot weighs 80.25 lbs.

Coke, - -	58.90	Ash, red, - - -	9.50
		Fixed carbon, -	49.40
Volatile matter,	41.10	Water, - - -	3.50
		Gas, - - -	37.60
	100.00		100.00

Coke not swollen, laminate, vitreous.

Lower part:

Two feet, eight inches.

Specific gravity, 1.229. One cubic foot weighs 76.81 lbs.

Coke, - -	61.50	Ash, dark red, - -	6.25
		Fixed carbon, -	55.25
Volatile matter,	38.50	Water, - - -	4.50
		Gas, - - -	34.00
	100.00		100.00

Coke not swollen, laminate, vitreous.
A fair article of block coal.

JOHN THOMAS' COAL M.

Sec. 20, T. 22, R. 8; caking coal, 20 in. thick.

Specific gravity, 1.415. One cubic foot weighs 88.43 lbs.

Coke, - -	62.00	Ash, red, - -	12.50
		Fixed carbon, - -	49.50
Volatile matter,	38.00	Water, - - -	4.50
		Gas, - - -	33.50
	100.00		100.00

Coke slightly swollen, laminate, lusterless.

TINKLER & CO'S COAL L.

Sec. 2, T. 20, R. 9; caking coal, 3 ft. 1 in. to 4 ft. 2 in. thick.

Upper part:

Seventeen inches, glossy black with conchoidal fracture.
Specific gravity, 1.257. One cubic foot weighs 78.56 lbs.

Coke, - -	53.50	Ash, pale red, - -	3.50
		Fixed carbon -	50.00
Volatile matter,	46.50	Water, - - -	3.00
		Gas, - - -	43.50
	100.00		100.00

Coke vitreous, slightly puffed, amorphous.

Middle part:

Eight inches; dull black, laminated structure.
Specific gravity, 1.282. One cubic foot weighs 80.12 lbs.

Coke, - -	50.00	Ash, blue, - -	3.00
		Fixed carbon, - -	47.00
Volatile matter,	50.00	Water, - - -	5.50
		Gas, - - - -	44.50
	100.00		100.00

Coke puffed, amorphous, vitreous.

Lower part:

One foot, jet black, laminated structure.

Specific gravity, 1.244. One cubic foot weighs 77.75 lbs.

Coke, - -	55.50	Ash, red, - - -	5.00
		Fixed carbon, - -	50.50
Volatile matter,	44.50	Water, - - -	2.00
		Gas, - - -	42.50
	100.00		100.00

Coke puffed, amorphous, vitreous.

CEDAR BLUFF IRON ORE.

Secs. 4 and 9, T. 22, R. 8. Iron stone in nodules forming a continuous band 8 to 10 in. thick.

Specimen No. 1.

Insoluble silicates	10.100
Protoxide of iron	47,862
Protoxide of manganese	.718
Alumina	2.490
Lime	3.330
Magnesia	.218
Loss by ignition, carbonic acid, water and undetermined	35.282
	100.000

Metallic iron, 37.24.

Specimen No. 2.

Insoluble silicates	11.700
Protoxide of iron	48.078
Protoxide of manganese	.837
Alumina	1.890
Lime	4.480
Magnesia	.230
Loss by ignition, carbonic acid, water and undetermined	32.785
	100.000

Metallic iron, 37.415.

This is a good and valuable ore. The iron exists, mostly, as a carbonate of the protoxide of iron.

GEOLOGY

OF

LAWRENCE COUNTY,

INDIANA.

BY JOHN COLLETT.

Lawrence county is situated in the southwestern part of the State, 75 miles south, southwest from Indianapolis. It is bounded on the north by Monroe, east by Jackson and Washington, south by Orange, and west by Martin and Greene counties, and contains 438 square miles. These outlines describe nearly a perfect square. The surface is agreeably diversified. The eastern and northeastern parts are undulating or gently rolling plateaus drained by deep narrow valleys, the central region north of White river is hilly, and the western and southwestern is rough and broken. Each of these divisions is covered with a soil almost wholly formed from decomposition of underlying rocks; we consequently find the soil in the first tenaceous clay and sand; of the second a calcareous clay, and of the third principally siliceous material, with an intermixture from both of the others. In that part of the county

underlaid by St. Louis limestone comprising a broad belt about 12 miles wide, passing centrally from northwest to southeast, "sink holes" are so numerous as to form a striking feature in the configuration of the surface. These sink holes are funnel shaped depressions, hewn down into the solid rock by rain fall charged with gases from the atmosphere, leading to a cavern or outlet in the underlying limestone. Sometimes the small parting at the bottom is filled or puddled with clay washed from the sides, and pools of water are formed; into some of these fish have been introduced. Many others ought to be so utilized. The larger basins of this nature give origin to streams of water which others in turn hide away in their capacious caverns.

The principal streams are the east fork of White river, and Indian, Salt, Leatherwood, Guthries, Sugar and Beaver creeks.

White river crosses the eastern boundary of the county three miles north of the southeast corner, and passes out of the county at a point almost exactly to the west. It is a broad, clean river, as large as the Wabash at Lafayette, flowing with a rapid strong current. It is a grand mill stream offering many eligible sites for works of great extent, with a low water capacity far in excess of any probable demand. The purity and coldness of the water derived from inflowing cave springs offers special inducements to paper makers. The river is generally belted, except where the stream impinges against precipitous bluffs of limestone, with broad alluvial bottoms of remarkable richness. The fertility of this formation is proverbial throughout the State, "As rich as the White river bottom," is the highest standard of excellence and may not be surpassed. Indian creek flows into the county from Martin, seemingly with the purpose of finding an outlet by Fayetteville to Salt creek, and after describing an arc of an absurdly crooked description, often turning back into sharp bends upon itself, returns in apparent disgust to its native county and sandrocks. The bottoms are narrow. The walls of its valley are generally precipitous or overhanging escarpments of

conglomorate sandstone. Salt creek enters near the centre of the northern boundary, and flows with sharp graceful curves in a southwesterly direction to White river. Near Guthrie this stream and its affluents have wide bottoms, entirely beyond the needs or erosive capacity of the present creek. Thence south narrow bottoms are found on either side of the creek, often of great fertility, but sometimes the soil, partaking largely of the aluminous nature of the bed shales, are cold and tenaceous. Several sites afford good mill power, which are profitably used. At spring floods the creek is a river; at low water a slow, lazy stream. Leatherwood has its source in the northeastern part of the county, and flows in a straight course southwest to White river. This creek is small, but somewhat reliable; it drives a woolen and other mills. Guthrie creek passes into the county near Leesville; although narrow, its valleys have a rich soil and are bounded by bold hills well timbered. Sugar and Beaver creeks are in the southern part of the county; from their course and peculiar connection with the ancient terraced flood plains which are seen near their sources, they were at some period a side or main channel of White river then flowing at a level 150 to 200 feet above the present channel, Many small brooks flow into these creeks; and fine springs, some of great volume, are common.

This county was originally heavily timbered, comprising, on the uplands, the usual varieties of oak, hickory, beach, maple and chestnut, with walnut, oak, elm, etc., in the bottoms, and valley lands. Bedford, the county seat, is pleasantly situated on the high divide between Salt creek and White river; and by Prof. Owen's determination is 680 feet above the level of the ocean.

GEOLOGICAL FORMATIONS.

The geological formations of this county comprise three divisions of the quaternary age, two of the coal measure group, and four of the sub-carboniferous groups.

These different formations are seen upon the surface or in

successive outcrops passing from the tops of the hills on the west to the bottom of the ravines on the east side of the county, all dipping at a variable rate towards west of south-west; consequently, in a few hours travel on the line of Ohio & Mississippi R. R., which runs directly across the dip of these strata, the geologist may see *in outcrop* a section measuring in vertical space about 700 feet. Sections taken at isolated points, present the following stratigraphic exhibit:

CONNECTED SECTION OF

LAWRENCE COUNTY, INDIANA.

QUATERNARY SYSTEM.

1.	Soil and clays....................	4	to	10.00
2.	Alluvium, recent.................	30	to	10.00
3.	Alluvium, ancient..........	450	to	40.00
4.	Loess..............................	20	to	5.00
5.	Boulder drift......................	00	to	0.00

CARBONIFEROUS SYSTEM.

Carboniferous Group.

6.	Lower coal measures...........	20	to	0.00
7.	Conglomerate (mill stone grit)	50	to	120.00
8.	Pyritous shale and shaly S. S. with bands and nodules of iron ore..................................	4	to	10.00

SUB-CARBONIFEROUS GROUP.

Chester Beds.

9.	Bituminous and argillaceous L. S. with coal measure and sub-carb. fossils mingled and alternately predominating...........	38	to	2.00
10.	Siliceous and bit. shale..........	0	to	9.00
11.	Place of a rash coal.............	8 in.	to	0.04
12	Thin bedded Sandstone, "Grindstone" and "Whetstone" grits	20	to	65.00
13.	Coarse heavy bedded S. S. (local)	6	to	0.00

14.	Blue argil. L. S. with black flints and chert....................	45	to	16.00
15.	Red and blue clay with plates of chert, passing into heavy argillaceous L. S. cement.......	12	to	5.00
16.	Coal bone, bit. slate.............	0	to	0.08

ST. LOUIS LIMESTONE.

17.	Gray argil. or bit. brecciated limestone, locally cement stone	20	to	4.00
18	Vermicular limestone...........	10	to	4.00
19.	Blue and gray argil. and magnesian L. S......................	35	to	10.00
20.	Bands of chert and amorphous geodes in shales and argillaceous limestones, which weather to a reddish brown clay, (paint), Lithostrotion bed and other corals...............................	5	to	40.00
21.	Blue quarry L. S. sometimes concretionary or breaking with conchoidal fracture..............	28	to	9.00
22.	White quarry limestone.........	4	to	12.00
23.	Oolitic limestone, fossil bed....	4	to	0.00
24.	Blue argillaceous limestone.....	5	to	30.00

KEOKUK BEDS.

25.	Blue and gray shales or limestone, with bands of chert......	0	to	10.00
26.	Geodes in blue shaly clay......	6	to	4.00
27.	Blue L. S. with Hemipronites etc.	3	to	6.00
28.	Geode bed with mammoth geodized fossils......................	2	to	3.6
29.	Shaly and "pink" limestone full of fossils, shells and crinoide stems.........................	2	to	1.6

KNOBSTONE FORMATION.

30.	Knobstone shales with thin beds of massive sandstone in its upper division......................	0 to 250.00
		677.00

SURFACE GEOLOGY.

The *Recent alluvium* bordering the different streams has already been mentioned. Its origin is due to causes now in action. Formed by the generous commingling of material derived from all the rocks through which the streams have wrought their valleys, and containing a large amount of vegetable matter, a rich, warm, marly loam is the general result. The White river bottoms are unrivalled for fertility. Shrubs and bushes grow to a wonderful size. Trunks of Wahoo (*Euonymus*) and spice-wood (*Benzoin*) were noted from four to five inches in diameter, or twice as large as I have seen them elsewhere. Walnuts, oaks, and other giants of the forest are of large growth.

The *Ancient alluvium* offers some features worthy of note. This deposit begins at the first benches above the overflowed bottoms, and may be recognized by terraces or beds of gravel and sand, thence to a height in extreme cases of over 300 feet. These record the ages which have elapsed, and mark the different levels at which White river and its affluents have flowed, since the beginning of our present system of water courses; characteristic sand-bars, etc., of this kind are seen at Whittaker's section 28, T. 5, R. 2 W., at "old Palestine," and on the summit of the highest hills N. W. from Bryantsville.

Next in date succeeds the *Loess*. This consists of ash gray siliceous clays, containing minute shells of animals now inhabiting a sub-tropical climate. It is found as originally deposited on the summit of the highest hills near Huron, and generally along the West line of the county. When undisturbed, this deposit presents a yellow color; but it is more frequently seen in a modified form and then has the noted typical gray color and compact texture. This soil is well adapted to the growth of fruit, and the persim-

mon is almost invariably present. This deposit is better developed in counties to the West and South. It is equivalent to the *Loess* of European geologists, or to the "Bluff formation" of Iowa and Missouri, and is referred to a period when lakes and broad currentless rivers occupied the central valley of the continent.

The *Bouldern drift* is the next deposit in sequence of time. It is typically a heavy bed of tenaceous blue and gray clays, generally unlaminated, containing a large amount of pebbles and boulders from the region of the great lakes, and deeply covers the northern half of the State. Great flows or bergs of ice are required to account for the transportation and pulverization of this mass.

In this county no *drift* deposits were seen, except pebbles and a few small boulders, found on the bars of creeks whose headwaters have their source to the north in the drift region; but as already mentioned, deep wide valleys, in size far beyond the present or possible usitude of the actual creeks flowing from north to south, are remarked: outliers of conglomerate and Chester sandstones are seen to east and west of Fayetteville, and near Springville, from two to four miles east of the present outcrop of the corresponding beds, which, by regularity of stratification, and susceptibility of identification, show that once continuous beds extended to or beyond these stations. The outliers are separated from the present beds by wide irregular valley plains which offer no evidence of fluviated erosion; the general topography shows that between these points, and in a broad belt extending from north to south, a little west of the center through the county, erosion on an extensive scale has taken place, sufficient to wear away and remove from 50 to 180 feet of solid rock; all these seem to point back to the period of the boulder drift, and indicate a time when the great iceflow, whether by glacier or berg, was obstructed by a barrier or ridge of rocks in the adjoining region to the north, where the great masses of ice melted and sent an avalanche of water down the steeply inclined surface of this county, producing the erosive phenomena here noted. Had

either solid ice or bergs been present, we would surely have found gravel and boulders. In Iowa and Illinois, a neighborhood about Dubuque and Galena, is noted as the "blue mound" region. Conical mounds, from 100 to 300 feet high, stand out on the prairie plains, their sides terraced by rocks of different geological formations, and their tops castellated by boldly escarped walls of Niagara limestone. Here the erosive action has been tremendous, and the phenomena can be explained only by calling into action the forces which seem to have exhibited such energy here.

These facts grouped in connected view, indicate the following sequence of events in the quaternary or most recent Geological age; after the old Tertiary sea which is so well developed west of the Mississippi river with its rich tropic flora of palms, spices and fruits, its wondrous fauna of giant mammalia and saurians, (according to Newberry* extending as far up the Ohio as Louisville), had retired.

1. The northern part of the continent was elevated to a great height, the surface rapidly sloping to the south. A period of intense cold condensed and partly congealed vast amounts of water, which by gravitation was driven southward. From the southern line of the ice a sheet of fresh water flowed with great violence cutting channels to a depth of from 50 to 150 feet below the present beds of our rivers. No animals are known to have existed here at that time, no life among these naked rocks, except a few pines, birch and cedars.

2. The surface was depressed to or below its present level. The ice line and rigorous climate retired to the north. A fresh water sea occupied the basin of the northern lakes, the surface of which was sometimes partially frozen, for we find boulders and pebbles on its shore lines, and in the sedimentary deposits known as the Erie clays. Another similar sea, having a sub-tropical temperature, occupied southwestern Indiana and adjoining regions to south and west. Either a difference in level, or a barrier connecting the

*Second Report of Progress.

Ozark and Cumberland mountains, confined this water, and overflowed the deep channels hewn out by the melted ice of the glacial era, to a depth of 400 to 600 feet. It was a quiet, waveless sea, for wave washed sands are not found along its shores. The climate was warm, for the few animal remains found in the Loess sand are sub-tropical, and few or no pebbles or boulders are met in shafting down into the black, mucky deposit of clay and vegetable remains, recognized as the sedimentary clay of this epoch; consequently we infer there was no ice to sieze upon the pebbles and stones and heap them up along the shore line or cast them down with deep water sediment. Sub-tropical plants as cypress, magnolia, white gum, persimmon, live oak, and monster vines were characteristic; and great sloths, beavers, saurians and marsupials of Australian or South American type, with the rhinoceros and elephant, were representative animals. It is probable that at this time, while the ice line still lingered and made obstruction at the mouth of the St. Lawrence, the great northern lake found discharge to the south by the valley of the Wabash at intervals, but finally secured an easy and uninterrupted outlet by its natural channel, the gulf of St. Lawrence. During this epoch, the chasms and thoroughfares previously hewn by the rapid torrents flowing from the melting glaciers, were partly filled up with sediment deposited by this great southern lake; hence in such old channels we find beds 50 to 200 feet in depth, of tenacious mucky clays and quicksands with much vegetable matter, the trunks of trees, etc., locally known as "Noah's cattle yard." Beach lines of this lake were marked with yellow sands and loams, while the shallows were covered with ash gray loess sands, becoming fine and impalpable as we descend to deep water.

3. An oscillation in the crust of the earth concluded the last epoch, elevating northern areas, and wasting away the barrier which obstructed this southern lake in its exit to the gulf of Mexico. The water level was gradually depressed, though stationary for long periods, and formed new shore lines of loess sand around the tops of high hills

and ridges. The rain fall gave current to arms and lagoons of the lake and formed sandy terraces. This process continued and repeated at intervals until the waters of the lake were entirely drained away, and the existing state of affairs was inaugurated. The creeks and rivers then commenced cutting their channels in the *more ancient valleys* now silted up. Terraces were formed on the hill sides of sand marking the high water line and flood plain of a stream, while lower are beds of gravel and coarse material marking low water riffles. White river, at an early period, evidently discharged through its valley a large volume of water with a powerful current; for in geology of Dubois county, ancient sand bars are noted 180 to 250 feet, and riffles bedded with geodes (evidently natives of the Keokuk rocks of Lawrence and Jackson counties) from 50 to 126 feet above the present channel of the river.

This erosive action has been continued during a long period, until the silted deposit has been almost wholly removed from the valleys, except so much as is found below the present channel of the streams. This undisturbed bed is found, where pierced, on lower White river in Knox county, to have a depth of at least 50 feet, and on the Wabash to extend down to from 60 to 90 feet below the present channel of the rivers.

Facts recently observed indicate that areas to the north are being depressed more rapidly than at the south; and if this is so, river channels in future will not be deepened. On the contrary streams flowing to south will become sluggish, and have their channels obstructed by bars and sands.

The foregoing surface deposits although theoretically above the underlying rocks and so described to properly fix the sequence of their occurence in time, it is hardly necessary to say are actually found resting upon and against the sides of the hills and reaching down into the deepest valleys.

PALEOZOIC GEOLOGY.

The order of succession and average thickness of the rocky formations has already been given. In the following general description the Nos. referred to are those of the general section; see page 264.

COAL MEASURES.

Commencing with the highest or most recent rocky formation on the western side of the county, we find thin beds of shales and shaly sandstones at the top of some of the highest hills belonging to the lower coal measures (No. 6 of section.) These beds are of no great extent, mere outliers, and the probability of their affording *workable* seams of coal is very remote.

CONGLOMERATE SANDROCK.

Below these beds is found the conglomerate or mill stone grit, a massive gray or brown sandrock, (No. 7.) This rock forms bold precipitous hills, and is well developed north and south of Silverville and thence to the southwestern corner of the county. Although generally pebbles are rare, yet at B. Williams' Sec. 8., T. 4. R., 2. W., an outcrop was seen presenting a pudding stone mass of hard, brightly colored or white pebbles. A pyritous shale No. 9 underlies the conglomorate, and by reason of the decomposing and disintegrating nature of the pyrite, rapidly wears away on exposure to the elements; and affords the usual "rock house" feature so common at this horizon. An example occurs on J. E. Bryant's land Sec. 19., T. 4., R. 2. W.

CHESTER FORMATION.

The upper member of this formation is a limestone exceedingly variable in its character, equivalent to the Kas-

kaskia limestone of Hall. The upper surface consisted of elevated hummocks, and valleys filled with iron stones and coal measure shales; in thickness it ranges from about 40 to 2 feet; and in color from whiteish gray to a dark brown or black, and when of last color, highly bituminous. Generally the fossils are emphatically of sub-carboniferous type, as *Archimedes*, *Pentremites* and *Crinoidæ*. At a few points these are mostly absent, and common coal measure fossils are found to predominate, as *Lophophyllum*, *Athyris subtilita* and *Productus Cora*. At such stations a rash coal, No. 11, is found. This coal is seldom of workable thickness in the Indiana coal field, and while variations to that rule are found to exist, such occurrences are rare. Poor returns and much disappointment will be the result of time and money spent in search of coal at this horizon.

Nos. 12 and 13 comprising the "grit stones" of Owen, are equivalent to the "Ferruginous sandstone" of Missouri. They consist of thin bedded sandstones showing a thickness south of White river of 65 feet, but thinning irregularly to the north. Throughout much of the region bounded on the west by the conglomorate, on the east by the underlying limestones, and extending from the southern line nearly to the northwestern corner of the county, this formation offers fair building stones and good grits. The fossils are *Stigmaria*, *Sigillaria*, *Lepidodendra*, (3 *sp.*), with cones, fruits and leaves, *Diplotegium*, *Ulodendron Cordaites*, *Pecopteris*, *Alethopteris*, *Neuropetris*, *Hyemenophyllites*, *etc.* At the base is locally found a coarse sandstone, which I am informed becomes persistent in adjoining regions to the south. The blue or gray argillaceous limestone, No. 14, is often very homogeneous, and from appearances will afford lithographic stone; but this can only be known by practical test. Good samples were seen and obtained on Dr. Johnson's, land Sec. 21, at Craig's mill, Sec. 17, both in T 5, R. 2 W., and on the bank of White river near Stump ford. In Beaver creek valley this stratum contains thick bands of dark hornstone which afforded the Indians a favorite article for the manufacture of flint weapons, and other fabrics of wrought stone.

No. 15 is pretty constant, a bed of red and blue clay with plates of chert passing into an argillaceous cement stone. It contains many silicified fossils, as *Orthocerata* a *Bellerophon*, *Nautili*, a *Zaphrentis* and *Syringopora*. No. 16—an attempt at a coal seam, is of no economical importance, except as an easily recognized stratum. It was found ranging from one to four inches thick at almost every outcrop in the county of the rocks ot this horizon. Good examples are seen at Pace's hill, Bedford, Avoca, Goose creek and Hamer's mill.

ST. LOUIS LIMESTONE.

As before remarked, this limestone occupies the surface in the central area of the country, commencing with a belt about 12 miles wide in the southeastern part, and widening to over 14 miles at Bedford; it thence narrows to less than 5 miles at the northwest. Taken as a whole or in each of its different strata it is so variable in thickness and character that no two sections will exactly correspond. Fossils alone are relied on for its identification. "Without the aid of fossils, which everywhere characterize this formation," scientists remark* "it would be utterly impossible to identify it at the various localities in consequence of the decided changes in its lithological character." Among the fossils most generally distributed and easily recognized are two corals of the genus *Lithostrotion*; *L. Canadense* (or "petrified wasps' nest") is found in masses of considerable size, composed of calyces of many angles, giving it the appearance of a honey comb in which the cells are enlarged to from three to eight times their ordinary diameter, the central area raised and pointed: in *L. proliferum* the cells are circular, sometimes massive or in tufts, but generally the calyces are solitary or disconnected. Worn specimens of the latter are locally known as "petrified corn cobs." With these may be mentioned *Productus* (*tenui-costus*) *Cora*, *Athyris ambigua*, *Zaphrentis spinulosus*, *Archimides*

* First Volume Illinois Reports.

Wortheni, *Pentremites conoideus* as common, together with many other fossils which will be found enumerated in local details at the place of their occurrence. When this limestone forms the surface rock, funnel shaped *sink holes* are numerous. Water collected and conducted by these give origin to caverns; for this reason the St. Louis has sometimes been called the Cavernous limestone.

The upper divisions and some of the lower strata are so highly argillaceous, that, on exposure to atmospheric influences, they break into angular fragments: re-cemented with lime dissolved and transported by water, it forms a brecciated mass. A good example of this is seen along the railroad about a mile south of Bedford. These beds from conchoidal fracture, and appearance of weathered fragments have hydraulic properties. Specimens were secured for chemical examination.

No. 18 of the section, a hard and compact limestone, is remarkably persistent whenever its horizon appears in the outcrop. It is named *vermicular limestone*, for the reason that it is traversed in all directions by cylindrical cavities from one-eight to half an inch in diameter, as if worm eaten. These cavities are supposed to be casts of sea weeds which have long since decayed. A curious form of crystallization, known as *crytallites*, is seen in this and some of the adjoining strata, consisting of a parallel system of crenulated columns, the opposing surfaces fitted to each other in a zigzag line. From their resemblance to the sutures in the human skull, Prof. G. C. Swallow has suggested the name of "*Suture joints*." Their origin has been attributed to pressure of heavy overlying masses, applied to the stone material while yet in a plastic state. No. 20 consists of beds of clay and argillaceous limestone containing plates and massive bands of chert and irregularly formed geodes, the whole mass disintegrating and combined forms beds of red and brown ochre. Some of these "*psuedo*" geodes seemed to have commenced crystallization at the center of a cavity, and when half formed to have ceased their growth. The cherts are highly fossiliferous; sometimes a band is

principally composed of thin layers of lace-like Bryozoans; from the shales, the creeks wash out silicified specimens of *Lithostrotion*, *Syringopora*, *Zaphrentis*, *Productus*, *Athyris*, *Sponges*, *Pentremites*, *Trilobites*, etc. A variety of sponge is found as the nucleus of the globular cherty concretions lcoally called "marbles" and "petrified plums." One of these, examined by Dr. Gardner with his excellent microscope, showed distinctly the characteristic "*spun-glass*" spicules. These balls are so numerous at places as to cover the surface; good examples are seen at Bedford, Mitchell, and Mr. Cole's farm, Sec. 7, T. 5, R. 1, W.

Nos. 21 and 22 constitute the most important quarry beds, and furnish a large amount of superior stone. The upper bed is sometimes argillaceous, and concretionary—in such cases inviting tests for hydraulic purposes; but at a few points it offers a stone suitable for chisel dressing, of remarkable solidity and of a dark, blueish color, desirable for water tables and line work in large edifices.

The lower bed No. 22, is the quarry bed which furnishes in unlimited supply the famous "*Bedford stone*" so favorably known and so much used in first class structures at Indianapolis, Cincinnati, Louisville, Springfield, Illinois, and St. Louis. This stone is composed almost wholly of minute fossils cemented with shell and coal dust. It varys in color from gray to a creamy white, and may be quarried in blocks or columns the entire thickness (12 feet) of the stratum, and without limit as to length. Homogeneous in structure, it is readily sawed or moulded by the chisel, into such forms as the architect may require. These qualities constitute a stone rarely surpassed; and the proprietor's of the Bedford quarries claim that it is not equalled by any stone in the Western States. Further particulars will be given in local details in Bedford Section, and under the head of Economic Geology.

Connected with this quarry-stone and generally forming its lower member is No. 23, the famous fossil bed, so well studied by Prof. Hall at Spurgeon Hill and Bloomington. It is from a few inches to three or four feet in thickness,

and is made up almost wholly of the shells and other remains of marine animals; some of them are microscopic and all are very small, yet as perfectly formed and symmetrical as if designed by a master's hand The bed affords about seventy species, of which the following genera are characteristic, viz.: *Rotalia, Phillipsia, Cythere, Chiton, Bellerophon* (2 sp.), *Pleurotomaria*, (3 sp.), *Murchisonia* (2 sp), *Natica, Loxonema, Bulimella* (2 sp.), *Euomphalus, Rhynchonella* (3 sp.), *Spirifera, Nucula, Chonetes, Athyris, Waltheimia, Terebratula, Retzia* (2 sp.), *Cono-cardium, Archeocidaris, Actinocrinus* (2 sp.), *Pentremites* (3 sp.), *Dentalium, Sphenopoterium, Aulopora, Coscinium, Archimides* and other *Fenestella.*

Good examples of this fossil bed may be seen on the Miller farm southeast qr. sec. 5, T. 5, R. 1 east, and in the valley of Spider creek west of Bedford: at the latter station this material has been subjected to chemical action while yet in a plastic state, probably to a long bath of therma water saturated with silica, which after dissolving the shell lime, replaced the cavities thus made with siliceous material, and forms an imperfect Buhr-stone.

No. 21 succeeds, and is sometimes when dark co :ı d charged with Petroleum, which flows out where the pores are ruptured or from crevices and cavities. At such localities it yields a compact bluish quarry stone, which properly seasoned, is of desirable quality, affording a stone that contrasts well with the light colored beds. Generally, however, it is argillaceous, and liable to break in splintery fragments; sometimes magnesian, with slight additions, a good cement may be manufactured from it. Its fossils are rare: a few *Pentremites* were found, with *Hemipronites crenistria, Productus cora* and *Spirifer striatus.* Throughout almost the whole area in which the St. Louis limestone forms the surface rock, the creeks and larger branches have cut their valleys down to the lower beds.

KEOKUK BEDS.

The upper member of this formation is of no economic

importance. In other regions it is rich in beautiful *Crinoidæ*; here but a few broken specimens of *Actinocrinus* were found. Near Heltonsville at the junction of this stratum with the geode bed, a curious crinoidal form was found apparently showing the internal structure or frame work of the animal. *Hemipronites crenistria*, *Productus punctatus*, *P. cora*, *P. semi-reticulatus*, *Spirifer striatus*, and *S. Keokuk* were the ordinary fossils.

No. 26 contains in a mass of shaly clay a wonderful collection of Geodes, locally known as "Nigger heads." Spherical in shape, rough and unattractive in outward appearance, these Geodes when broken open present a never ending variety of nature's most beautiful work. They vary in size from one inch to one foot or more in diameter. Generally hollow, the internal mass is composed of crystalized silica, with cavities lined with pure limpid, black or rose colored crystals, or chalcedony; and occasionally containing calc spar, or double-ended or twin crystals. Mingled with the last, zinc blende, galena, and pyrite is rarely found. The second geode bed No. 28 presents all the varieties above mentioned, but in addition affords quite a number of geodized fossils as *Spirifera*, *Bellerophon*, *Zaphrenti*, *Gonitiates*, *Crinoid* heads and stems, *Palæchinus* and *Nautili*, all of giant size. These are so numerous and so unmistakably distinct, that we may infer *that animal remains caused the cavities and gave initial direction to the form of many, if not all the geodes.* Good beds are seen at Ft. Ritner, Leesville, Heltonsville, Bartlettsville and Guthrie.

The stratigraphic position of No. 28 of the general section would assign it to the formation known as the "Burlington limestone" by Iowa and Illinois geologists, but not having found distinctive fossils, for the present it is included with the Keokuk formation. It consists of shaly and hard pink limestones profusely filled with disjointed stems of *Crinoidæ* and *Pentremites*, and in addition contains *Hemipronites crenistria*, *Spirifer striatus*, *S. Keokuk*, *S. Kentuckensis*, *S. lineatus*, *Productus cora*, *P. semi-reticulatus*, *P. punctatus*, *Archimides Oweni*, *Aulopora*, *Chetetes*,

Zaphrentis, *Pentremites*, and a few specimens of *Actinocrinus*. In almost every locality where the "pink" or chocolate color prevails, shark's teeth of the genera *Helodus*, *Cladodus*, *Cochliodus* and *Deltodus* are found. Good outcrops of this bed may be seen near the water line along the lower half of Salt and Leatherwood creeks, at the top of the hill west of Guthrie, at Hamer's railroad cut near Rivervale, and generally on the high lands between Ft. Ritner and Heltonsville. As a quarry stone, this lime rock is very compact, and affords some good material for foundations and hammered masonry.

KNOBSTONE SHALES.

This formation is the lowest visible in the county. Its whole extent is nearly 500 feet thick, of which about 250 feet outcrops in the eastern and Southeastern parts of the county. The whole is principally composed of dark aluminous shales, compact and tenaceous, but decomposing on exposure to the air, and readily yielding to the action of running water, hence the creeks and brooks have cut deep valleys with precipitous sides, and ramifying in every direction have moulded the surface near the water courses into a continuous system of sharp, conical hills or "Knobs," which give appropriate name to this formation. The circumstances under which these shales were deposited was not favorable for the preservation of animal remains. Fossils are rare. The following only were found: *Spirifer capax*, *S.* (*sps ?*), *Productus cora*, *P. semi-reticulatus*, *Pleurotomaria ?*, *Hemipronites crenistria*, and *Athyris lamellosa ?*, all in a poor state of preservation.

The upper member of the Knobstone contains locally bands and thin beds of homogeneous sand stone, which is enduring, and may be sawed or cut with facility. This rock is equivolent to the celebrated "Waverly sandstone" of Ohio, and invites the attention of manufacturers of wrought stone. Outcrops are seen at Ft. Ritner, Guthrie, and throughout the eastern side of the county.

To the foregoing general description will be added local observations and representative sections.

LOCAL DETAILS.

The court house at Bedford is a stone structure, commodious, neat and substantial. It is built of material obtained from quarries in that immediate vicinity, so well known as "*Bedford Stone*," and doubtless will prove a good investment to the tax payers of the county as a demonstrative advertisement of the vast quarry beds which surround the town. The high school, well situated upon a commanding elevation, is of brick ornamented with stone. It challanges comparison with similar structures in the cities. The chert bed of the St. Louis limestone, which on disintegration forms a reddish brown ochre, colored with hydrated oxide of iron, outcrops at all the hill tops around town, and may be considered the surface stone. It is from twelve to forty feet thick, and is composed of beds of gray, green or red shales, enclosing bands of chert and flint from two to twelve inches thick. No outcrops of this strata in place could be found, as on exposure to the air the clay crumbles away and the chert breaks into small angular fragments. A band of soft white chalky material, though not found in place, occurs frequently and appears to be persistant. It contains some fagmentary fossils, but is principally composed of well preserved whorls of *Archimides*.

The following sections taken at Borland's mill on Spider creek, and at Campbell's cave a mile south of town, show close parallelism:

SECTION ON SPIDER CREEK.

Clay and chert	30 ft. 00 in.
Argillaceous limestone and shale	8 ft. 4 in.
"Coal bone"—slate rich in petroleum	3 in.
Hard, gray bituminous limestone	3 ft. 6 in.
Vermicular limestone	4 ft. 4 in.

Laminated bituminous limestone........	5 ft. 00 in.
Blue argillaceous limestone, with *Productus semi-reticulatus*, *P. Cora*, *Atthyris lamellosa?*, *Terebratula* and *Fucoides*, breaking with conchoidal fracture, indicating hydraulic qualities........................	8 ft. 00 in.
Indurated limestone, containing *Pentremites* and Spurgeon Hill fossils......	12 ft. 00 in.
"White quarry" limestone..............	15 ft. 00 in.
Blue limestone in creek..................	8 ft. 00 in.
	94 ft. 05 in.

SECTION AT CAMPBELL'S CAVE.

Clay and chert......	10 ft. 00 in.
Bituminous limestone......................	2 ft. 6 in.
"Coal bone"—slate........................	3 in.
Dark bituminous limestone, laminated	2 ft. 00 in.
Argillaceous limestone......................	2 ft. 00 in.
"Vermicular" limestone.................	4 ft. 00 in.
Hard gray limestone.......................	4 ft. 00 in.
Compact argillaceous and magnesian limestone................................	6 ft. 00 in.
Blue hard limestone	10 ft. 00 in.
"White quarry" limestone, to water..	9 ft. 00 in.
	49 ft. 9 in.

Campbell's cave is known to be half a mile in length, but was too muddy at the time of my visit for pleasant exploration. On the hill above were noticed "waxberry myrtle," "mouse-eared plantain" and *Gnathalium* or "Ditny."

Half a mile west of Campbell's, and a mile and a half southwest of town, is Dunnehew's, the most extensive cavern known in the county. It has been explored through a space of two miles, and is said to contain beautiful stalactites, stalagmites and chambers of considerable

size. At "Leatherwood cut," on the railroad south of Bedford, the rocks which constitute the base of the St. Louis, and top of the Keokuk beds are argillaceous, the quarry limestone evidently having thinned out. In "pockets" are found *Pentremites conoideus*, *P. Woodmani*, *Batocrinus*, *Cyathocrinus*, a *Phillipsia*, *Productus punctatus*, *Spirifer Keokuk*, *Aulopora*, and large whorls of *Archimides*. Half a mile north, the hill on the west side of the railroad is composed of angular fragments of limestone, re-cemented with tufa. Such fracture would naturally result if the bare hill was exposed to the air; and water leached through the overlieing calcareous earth, would, in the course of time, fill up the interstices. This theory accounts for the phenomenon without calling to our help earthquake or other violent agencies. In the shaded or cavernous sides of this brecciated hill, a blue color was noticed tingeing the recesses of the rocks, which was thought might be the stain of copper, but on submitting a specimen to Dr. Gardner's microscope it was at once recognized as a fungous growth. A similar incrustation was noticed on the housed rocks at the old railroad quarry near Scottsville.

Proceeding north a stratum is seen at the next cut, from four to nine feet thick, which from its splintery fracture and weathered appearance invites experimental tests for hydraulic qualities. Specimens were secured for the State cabinet and analysis. Coats' and D. Johnson's quarries, one mile south of Bedford, near the Louisville and Chicago railway track, have been long in work. The "white stone" may be obtained in columns or blocks, ten feet square at base, and of any reasonable length. Columns twenty feet long were seen in the yard. It comes soft from the quarry, may be sawed by hand or power, is easily chisseled and is well suited for door and window caps and sills, columns and highly ornamented capitals and brackets. The lower bed, after seasoning, withstands the action of frost and weather well; gray or blue colored, it affords a striking contrast with the "white," and is used for water tables and string courses by architects.

The following section shows the extent of the quarry:

COATS-JOHNSON SECTION.

Hard laminated limestone..............	4 ft. 00 in.
White quarry stone........................	10 ft. 00 in.
Blue quarry stone.......	7 ft. 00 in.
	21 ft. 00 in.

At Coats' quarry a few casts of a large *Bellerophon* were noticed, occasionally having their internal cavity filled with petroleum or asphalt. At N. L. Hall's quarry the following section is seen:

HALL'S QUARRY.

Soil and clay................................	4 ft. 00 in.
"White limestone".......................	9 ft. 00 in.
Blue limestone to bottom of quarry...	4 ft. 00 in.
	17 ft. 00 in.

Great energy and skill is shown by the proprietor of this quarry. Commencing without capital, he has by industry created a business and character worthy of emulation. His territory is ample, and a powerful engine drives three gangs of saws. The demand for his manufactures has exceeded the capacity of his mill, and it is intended to double the number of saws the coming year.

The white stone comes soft from this bed and is sawed with facility, but tough under the stroke of the chisel, is carved into handsome monuments, columns, capitals, brackets, mouldings, etc. Specimens of the product may be seen in the following structures, viz: The Bedford Court House; U. S. postoffice, Indianapolis; State University, Bloomington; the new State House, Springfield, Illinois; for coping and posts at Lincoln Park, and in the Custom House at Louisville, etc.

The "blue stone" is harder and finer in texture and furnishes a grateful contrast in colors. A large demand has

arisen for coping and posts to support iron fences about cemeteries, and for monumental purposes.

Stone from this quarry has been tested by competent engineers and architects, and it is found to have cohesion sufficient to resist the compression and cross-strain of large structures.

A wall of this material, it is estimated will prove three times as strong, and more than twice as enduring as a wall of well burned bricks. Columns of any size, within the limit of railway transportation, may be obtained, and blocks have frequently been shipped measuring one hundred cubic feet. Fragments from the quarry are burned and produce a good article of lime. Mr. Hall spread the refuse from his lime kilns on an old worn out field, which no longer paid for cultivation, applying less than twenty bushels per acre. The first year showed marvelous improvement and made the crop of 1873 equal to the average of virgin ground. Other experiments in liming for manure, I am informed, have proven equally profitable. Whitted's quarry, a mile west of Bedford, was formerly worked. The stone is easily quarried, works well, and is said to be of superior quality.

Near by, on the land of Jacob Viehl is a moderate flow of "*White Sulphur*" water, strongly charged with sulphuretted hydrogen. It deservedly has quite a local reputation for medicinal properties. Leaves covered with this water were noticed shining with tints of red and yellow. On examination the color was found to be due to the presence of myriads of animalcules of the lowest order of life, merely a sack or cell with an investing membrane, but all alive with motion. This animal closely resembles the "red snow fungus," and would be probably so classed did not celerity of action indicate animal life. These and many other microscopic studies found on the mosses offer an interesting field for the naturalist.

Passing to west, northwest, east and southeast from Bedford, as we descend into the valleys of Salt and Leatherwood creeks, full outcrops of the whole depth of the St. Louis

limestone may be seen amounting to about one hundred feet. Well preserved fossils are not common, but myriads in a fragmentary condition may be seen, comprising the following genera and species:

Batocrinus, *Actinocrinus*, *Dichocrinus*, *Pentremites conoideus*, *P. Woodmani*, *Archimides Wortheni*, *Coscinium asteria*, *Aulopora*, *Zaphrentis spinulosa*, *Bellerophon levis*, *Athyris ambigua*, *Terebratula*, *Platyceras*, *Pleurotomaria*, *Productus cora*, *Rhynchonella*, *Phillipsia*, etc: At the base of the hills near the water line in each of these valleys, occur the geode beds and lanimated limestones of the Keokuk formation, having a thickness of twelve to twenty feet, and containing excellent specimens of *Hemipronites crenistria*, *Productus cora*, *P. semi reticulatus*, *Spirifer Keokuk* and *S. striatus*. At some of these localities the "white" quarry limestone, equivalent to Warsaw limestone of Iowa, is reduced to a thickness varying from a few inches to less than two feet, and is replaced with hard, gray argillaceous lime rock, showing that the Warsaw beds are not absolutely persistant.

Northeast from Bedford on the Heltonsville road, N. W. qr., Sec. 8, T. 5, R. 1 E., below the white quarry bed, is a fine outcrop of the "Spurgeon Hill" fossils. In a stratum less than two feet thick the following were found:

Phillipsia (*sp ?*), *Rotalia Bayleyi*, *Cythere carbonaria*, *Chiton carbonarius*; joints, plates and spines of *Platycrinus*, *Batocrinus* and *Actinocrinus*; plates and spines of *Archeocidaris Wortheni*, *Pentremites conoideus*, *P. Woodmani*, *Coscinium asteria*, *C.* (*Sp ?*), *Aulopora*, *Zaphrentis spinulosa*, flanges of *Archimides Wortheni*, *Sphenopoterium cuneatum*, *Conocardium cuneatum*, *Spirifer*, (*sp ?*), *Productus cora*, *P. muricatus?*, *Nucula*, *Myalina*, *Cypricardella*,? *Rhynchonella sub-cuneata R.* (*s ?*), *Athyris ambigua*, *A.* (*?*), *Retzia Verneuilanum*, *Waltheimia* (*Sp ?*), *Euomphalus planorbiformis*, *Pleurotomaria* 3 sp., *Murchisonia* 2 sp., *Bulimella* 2 sp., *Natica Littonana*, *Bellerophon laevis*, *Platyceras acutirostris*, *Terebratula hastata* and *Dentalium primarium*, with some undiscribed forms. A short distance

to the north of this station, a coarse blue limestone with characteristic Keokuk fossils is found near the bottom of the hill and accompanying geodes; with the latter the bottom of Leatherwood creek was found covered.

At the Miller farm N. E. qr., Sec. 4, T. 5, R. 1 E., the following outcrop showing junction of the Keokuk limestone with the knobstone shales was seen. Viz:

SECTION AT MILLER FARM.

Soil and clay..........	25 ft.	00 in.
Geode bed................................	5 ft.	00 in.
Blue Limestone with *Hemipronites* and *Productus cora*.................	4 ft.	00 in.
Geode bed................................	3 ft.	6 in.
Coarse limestone with joints and plates of *Crinoidæ*..................	1 ft.	2 in.
Shaly limestone........................	2 ft.	6 in.
Coarse limestone.........	1 ft.	0 in.
Knobstone-dark, gray, red and yellow shales........	60 ft.	0 in.
	—	—
	101 ft.	2 in.

At Rollins' mill the following outcrop was seen just below the dam, viz:

ROLLINS MILL SECTION.

Chert, fragmentary.....................	20 ft.	00 in.
Argil. and vermicular limestone...	15 ft.	90 in.
Argil. limestone—Pentremital......	8 ft.	00 in.
Gray limestone	30 ft.	00 in.
Keokuk limestone with Spirifers, Geodes, etc...........................	12 ft.	00 in.
Keokuk reddish limestone with Crinoid joints *Productus* and *Hemipronites*........................	7 ft.	00 in.
Knobstone shales and siliceous limestone with large *Nautili*......	16 ft.	00 in.
	—	—
	108 ft.	00 in.

The tops of the hills around Springville are capped with outliers of the Chester formation. A mile east of the village near the summit of the hill is an outcrop of the upper Chester (Kaskaskia Limestone) crowded with crinoid joints and including *Pentremites obesus*, *P. pyriformis*, *Zaphrentis spinulosa*, and *Chonetes variolata*. The small band of coal usually underlying this limestone was not seen.

In this neighborhood unusual attention has been given by farmers to "shrubbing" and preparing their land for the culture of grass, for which the soil is naturally well adapted. In the bed of Goose creek, on the farm of Ed. Turney southeast quarter Section 30, T. 6, R. 1, W., was seen the parting of coal bone, having a strong odor of petroleum, which so persistantly appears in the upper division of the St. Louis limestone. At Avoca on the farm of Owen W. Owens, is a *White Sulphur* Spring, which deservedly has a good local reputation. It acts as a laxative, tonic, anti dyspeptic, and febrifuge. For bathing it is found highly efficaceous in diseases of the eye and the skin. The water is strongly charged with sulphureted hydrogen gas, whose antiseptic qualities are well known. Close by is a salt well, bored to a depth of 160 feet about the year 1814. Salt was made here for sometime, but the manufacture has been abandoned for more than 50 years; another thin outcrop of black bituminous slate was seen in the brook adjoining. Lower down Salt creek on the land of Abram Reynolds northeast quarter Section 8, T. 5 R. 1, W, an additional salt well was bored many years ago; at a depth of 90 feet the workmen found a bed of black material and reported a seam of coal six feet thick. The well was commenced below the St. Louis limestone, continued into the Knobstone formation, and at about the horizon where the coal was reported there is a bed of black, tenaceous bituminous clay (as may be seen in Leatherwood below Heltonsville); this was mistaken for coal, which is never found at or below the St. Louis limestone.

Continuing south one mile, an outcrop is seen on the land of Alfred Pace northwest quarter Section 17, T. 5, R. 1, W, comprising the lower part of the Chester and upper member of the St. Louis limestone.

SECTION AT PACE'S HILL.

Red drift, with fragments of coal	20 ft. 00 in.
Dark sandstone	3 ft. 00 in.
Shaly sandstone	10 ft. 00 in.
Gray chert	1 ft. 6 in.
Shaly sandstone	4 ft. 6 in.
Dark laminated limestone	5 ft. 00 in.
Blue St. Louis limestone	6 ft. 00 in.
Vermicular limestone	10 ft. 00 in.
Place of "*coal bone*"	3 in.
Blue and white argillaceous limestone	15 ft. 00 in.
Yellow magnesian limestone	6 ft. 00 in.
Shaly argillaceous limestone—geodes	8 ft. 00 in.
Blue Pentremital limestone	22 ft. 00 in.
	110 ft. 9 in.

Mr. William Boyd reports that at an early day he assisted in digging a well near his residence, S. E. qr. Sec. 7, T. 5, R. 1 W. At a depth of eight feet he found a bed of soft yellow substance from which silver was said to have been obtained. He proposes to open this well and make a complete examination. The well was commenced in a "sink" below the "chert bed." This horizon outcrops at several points in the neighborhood, and at those places, no evidence was observed indicating the existence of silver ore. In the "Silver Sink" some choice specimens of silicified *Fenestella* were obtained.

At Shiloh mill, S. E. qr. Sec. 19, T. 5, R. 1 W., the following section was taken, the cut for the mill race affording unusual facilities for observation :

SECTION AT CAVE MILL.

Chert and covered	50 ft. 00 in.
Banded blue limestone	12 ft. 00 in.
Chalky white clay	4 ft. 00 in.
Siliceous and calcareous shale	3 ft. 6 in.
Black bituminous shale, "coal bone,"	3 in.
Shaly limestone, St. Louis	1 ft. 00 in.
Hard blue limestone	3 ft. 4 in.
Laminated blue limestone	2 ft. 00 in.
Brecciated soft limestone	3 ft. 2 in.
Vermicular limestone	4 ft. 6 in.
Massive limestone	28 ft. 00 in.
Covered	20 ft. 00 in.
Oolitic quarry limestone	40 ft. 00 in.
	171 ft. 9 in.

The mill was formerly driven by water brought through a tunnel from the cave.

SHILOH CAVE.

The entrance to this cavern is on the side of a sink whose funnel once collected the water which tunnelled a pass way thence to Salt creek, three-fourths of a mile distant. Descending a short rugged slope, a wide room, thirty feet in hight, is found. The moist air and the brook babbling over the floor justify the name by which it is sometimes known: "Wet Cave." Bewildered by darknesss and the novelty of the situation, an oppressive awe startles the mind and ear as strange mocking voices are cast up from the black depths. A lofty hall leads off in a southeasterly direction, the precipitous sides of which show stratified beds of limestone; and fragments of chert from the roof prove the horizon to be the cherty or upper member of the St. Louis. The echoing noises increase as we proceed, and soon a natural fountain is perceived, which pours three jets of pure silvery water from an orifice near the roof down upon the floor, from which a cloud of spray arises.

The cold water is grateful and refreshing. Proceeding across the small brook the lofty sides are draped and festooned with stalactites, sometimes hanging in graceful folds, or ribbed with giant corrugations. Above, the roof and overhanging sides bristle with clear, quill-like tubes, fragile as glass, each tipped with a drop of water which sparkles in the lamplight like a crystal jewel. Passing on for half a mile the beauty and purity of ornamentaton does not flag, although frequent crossing of the brook, now of considerable size, becomes tedious. Here it leaps from a small precipice with much report of "falling water." The pond below blocks the way, but with waterproof boots, the southern outlet may be found a fourth of a mile beyond, near Salt creek. Several side passages have not been explored, and will reward some future Columbus. Near the middle of the cave was a stalagmite as large as a man's body, five feet high, named the "Image of the Manitou." Some ruthless iconoclast has broken the statue, and scattered the fragments on the floor. This cavern far exceeds Mammoth cave in beauty, and rivals any that I have ever seen, though only one mile has as yet been explored. The temperature of external air, Nov. 15, was 55°, of the cave, 69° Fah. Inhabitants, as noted by tracks, etc., were coons, rats and ant-lions.

DRY CAVE.

This cave has its doorway on the side of a hill in the N. E. part of Sec. 12, T. 5, R. 2, thence in a southeasterly direction it underruns part of Sec. 7, T. 5, R. 1 W., and in connection with the intervening valleys on the land of Mr. T. C. Cole and others, once probably formed a junction with Shiloh cave. The horizon is partly in or just below the heavy chert band of the St. Louis. The top of the hill holds an outlier of Chester sandstone, containing coal plants fossilized. A narrow doorway opens into a lofty vestibule, whose arched dome is twenty-five feet above the floor, with a few stalactites upon the walls; soon the cave is apparently ended; a monumental altar rises in the center of the

passage, guarded around with pendant stalactites which almost hide the tablet with their snow-white shield. From these a curtain, scarce half an inch thick, draped in graceful folds, and caught in stone, is thrown across the passway. The curtain is rent, broken by some sacrilegious hand. Immediately beyond, from a projecting cornice, ten feet above the floor, thousands of stalactites fringe either wall of the passage with a profusion of ornament. Behind the altar a mighty stalagmite has grown up to support, like a pillar, the roof above. Beyond, we ascend by a ladder to an upper floor, and thence in large roomy halls, showing many interesting forms of stalactites and stalagmites which relieve the otherwise gray or yellow walls, we find the termination of the cave. It is inhabited by rats, mice, ant-lions and crickets—all observed, were seeing animals. The deepest point below the floor of the vestibule was twenty feet; temperature 68° Fah. The chemical processes resulting from decomposition, etc., of the different salts of magnesia and lime, produce in the cave an atmosphere remarkably free from moisture, highly antiseptic, and consequently equal to a first-class "fruit house" for the preservation of animal or vegetable food. Advantage has been taken of this fact by farmers, who sometime deposit for preservation in this and other dry caves, the carcasses of their slaughtered animals, and their winter supplies of apples, sweet potatoes, etc. The floor of the cavern contains much loose clay which is highly charged with nitre.

GRINSTAFF'S CAVE.

This cavern has its entrance in south half of Sec. 10, T. 5, R. 2 W. It was not entered, but information obtained from visitors, gives the following description:

It consists of two stories or floors, the upper one dry, the lower one washed by a small stream of water. As yet it is only partially explored; many passages have not been entered at all, but the fact that the parts already visited have a length of more than two miles, shows that it is extensive. The sides are ornamented with a variety of stalactites,

some of translucent spar, and there are quite a number of columnar or spheroidal stalagmites.

Fayetteville is surrounded by a thrifty agricultural community. The soil, generally of a reddish brown color, is derived from the upper member of the St. Louis limestone, and produces fair crops of corn, wheat and clover. Several good fields of blue grass were noticed. Sink holes are very common, and the rocks beneath are tunneled with caverns. At every outcrop of the cherty surface rock, fine massive specimens of *Lithostrotion Canadense*, *L. proliferum*, a *Syringopora* (*inds.*), and shaggy lumps of chrystals are found. These are used by some of the citizens to form ornamental rock work mounds in their door yards. Many localities are rich with single calyces of *Lithostrotion* ("petrified corn cobs"), *Zaphrentis spinulosa*, *Bryozoans*, *Productus cora*, *Athyris ambigua*, *Bellerophon levis*, *Orthoceras* (s?), and plates and spines of *Archeocidaris Wortheni.*

The following section commences at the valley about one mile west of Fayettevile, and is continued along the hill for a space of half a mile:

FAYETTEVILLE SECTION.

Coarse sandrock	30 ft. 00 in.
Bituminous limestone, with fossils	6 ft. 00 in.
Shaley coal	00 ft: 6 in.
Laminated fire clay	2 ft. 6 in.
Blue and gray shale (pryritous)	25 ft. 00 in.
Covered (Chester sandstone?)	40 ft. 00 in.
Blue and gray limestone with a large *Bellerophon, Orthocerata, Euomphalus*, etc.	35 ft. 00 in.
Chert bed containing St. Louis fossils in abundance	40 ft. 00 in.
	179 ft. 00 in.

The coal here worked by James Tannehill will burn, although slaty. The outcrops do not indicate the proba-

bility of a workable bed. On the adjoining farm of Dr. W. R. Johnson is a stratum of compact siliceous limestone, very homogeneous, in laminæ of from two to four inches, which closely resembles lithographic stone, and invites a careful test' The stratum is fully four feet thick.

At Robert Gray's mill on Indian creek, S. E. qr. Sec. 17, T. 5, R. 2, W., the limestones are rich in characteristic fossils. In the bed of the creek quite a number of springs burst up through crevices in the bed-rock, discharging "white sulphur water" accompanied with sulphureted hydrogen. They will be found to possess the medicinal properties appertaining to similar springs. They are valuable.

At Michael Wagner's, Sec. 19, T. 5, R. 2 W., a thin seam of slaty coal has been opened. The following section was observed:

SECTION AT M. WAGNERS.

Conglomerate sandrock in hillside, and covered	90 ft.	00 in.
Bituminous or gray limestone	12 ft.	00 in.
Black slate and Coal	00 ft.	10 in.
Pyritous shale	10 ft.	00 in.
Blue limestone to branch	8 ft.	00 in.
	120 ft.	10 in.

From the bluffs near Silverville across the valley of Indian creek, outliers of sandstone are seen on sections 16 and 21, T. 5, R. 2 W. Some are sharp conical mounds, symmetrical as if shaped by hand for monumental purposes, and show that erosive currents of water have acted upon the summit of these hills. They are known as the "Hay stacks."

FAYETTEVILLE HEMATITE BEDS.

Four miles southeast from Fayetteville, in beds of sand deposited on the top of hills, several hundred feet above the present level of the water courses, beds of rich iron ore are

found. The principal developements have been made by the "Southern Indiana Iron Company" on the land of Geo. W. Whittaker Section 28, T. 5, R. 2, W. Ore is also found at different levels on the adjoining farms. Test shafts put down to a depth not exceeding nine feet, at fourteen different stations in Section 28, discovered the ore in each, varying in thickness from two feet four inches to four feet (on the Fordyce tract), and averaging, according to measurements reported, not less than three feet. But one pit was free from water, etc., at the time of my visit: in this the ore was fully three feet thick, with a four inch parting of clay near the centre. One sample of Whittaker's ore analyzed by Prof. Cox gave the following results:

WHITTAKER'S HYDRATED BROWN HEMATITE.

Moisture and combined water	13.000
Silicic acid	0.900
Ferric oxide	84.890
Alumina	trace
Phosphoric acid	0.145
Carbonate of Lime	1.000
	99.35

The *ferric oxide* reduced gives 59.426 per cent. of metallic iron. Booth's Encyclopedia of Chemistry gives a table of iron ores in per centages which is quoted for comparison:

Magnetic ore—metallic iron	70.5 to 50. 9
Specular ore—metallic iron	45.8 to 51.17
Hydrated ore—metallic iron	35.5 to 49. 9
Whittaker's ore—metallic iron	59.42

From this it appears that the Lawrence county Hematite is unrivalled. Excluding the water, it is freer from deleterious ingredients than ordinary cast iron, and will be of great value for the manufacture of Bessemer steel. Other beds

mentioned by Mr. Whittaker as occuring at lower levels, were covered at the time of my visit and not seen. The "Shoals Iron Company" intend building a tram way from the mine to White river, distant two miles, thence making use of water transportation to their furnace at Shoals.

A high range of hills on the north of White river, extends from the west side of the county nearly to Salt creek. They are generally capped with different members of the Chester formation, and in extreme cases attain a height of 595 feet above the river. Near the palatial residence of Barton Williams in the southwest corner of Indian creek township, occurs a typical bed of "pebbly conglomerate," and a stratum of fibrous spar having a faint tinge of blue color: the latter has apparently the specific gravity of "heavy spar" (Barytes), but the structure, color, etc., is that of Celestine (sulphate of Strontia). For determination I refer to the Chemist's report.

Good examples of the overhanging, or "rock house" character of the conglomerate or mill stone grit, are seen on the land of Col. J. E. Bryant, Sec. 19, T. 4, R. 2, W., on the opposite side of the river. Here the Chester beds are changed to siliceous shales. Fragments of coal, from a small, covered seam, were found in the talus of the hill, near the water level.

SECTION ON COL. BRYANT'S FARM.

Massive conglomerate.......	125 ft. to	70 ft. 00 in.
Laminated sandstone		15 ft. 00 in.
Bituminous limestone......		10 ft. 00 in.
Silicious shale—place of coal........................		20 ft. 00 in.
Shale and limestone to White river.............		50 ft. 00 in.
		165 00

Crossing a high range of hills to the south, capped with *Loess* and containing much sandstone with frequent outcrops of iron ore, we descend to the valley of Beaver creek.

The region about Huron is eminently a timber country. A large amount of cooper stuff, poplar and other lumber, is prepared and shipped from this station. Advantage is taken by the enterprising citizens of the *equalization of temperature* found to exist on the summit of the surrounding sharp hills, which are two hundred to two hundred and fifty feet high, to plant extensive orchards, which produce highly remunerative crops of excellent fruit. It has been frequently observed here that in cold weather ice of considerable thickness forms in the valley, when no frost has fallen upon the hills just above. This arises from the fact that cold air is heavier than warm air, and in obedience to gravitation descends, and may fill the valley, leaving the peaks above bathed in warmth. Mr. Late. Prosser has an orchard of eighteen hundred peach trees, seventy-five pear trees and nine hundred apple trees, of improved budded or grafted varieties. Mr. John Terrell's orchard includes two thousand fruit trees of choice selection. These, notwithstanding the extreme rigor of the winter* of 1872–3, which caused such destruction of the orchards of Central Indiana, remain prolific and uninjured. Such facts invite the attention of fruit growers.

Undeveloped outcrops of silicious iron ore were seen on the lands of T. Snow, L. Prosser and J. Connelly. Workable beds are possible, but not probable. The "iron mountain," on the Marley farm, west of town, exhibits a wonderful amount of silicious ore, which although not pure enough to work alone, it is believed will prove valuable for fluxing specular ores.

The following shows the succession of rock on the surface; and in a well put down at the steam mill, viz:

*Mr. Prosser informs me that during that severe winter the thermometer indicated—22° in the valley, and the peach trees in the valley perished; at a hight of one hundred and fifty feet the trees survived, and two hundred feet above the valley, the trees not only lived, but bore a full crop of fruit the next summer (1873).

SECTION AT HURON.

Conglomerate sandrock, with wedges and pockets of white sand........	40 ft. 00 in.
Bituminous limestone with *Spirifer incrassatus*, *S. lineatus*, *Productus cora*, *P. Semi-reticulatus*, and *Athyris subtilita*..0...........	18 ft. 00 in.
Place of rash coal..............	4 in.
Thin bedded Chester grit stones......	65 ft. 00 in.
Heavy bedded Chester grit stones.....	6 ft. 00 in.
Blue limestone............................	16 ft. 00 in.
Red and blue clay.........................	2 ft. 00 in.
Soapstone and pyrite......	4 ft. 00 in.
Black slaty coal..........................	0 ft. 8 in.
Soapstone	1 ft. 8 in.
Gray limestone with flints.............	16 ft. 00 in.
	129 ft. 8 in.

Half a mile west of the village the Chester beds were once extensively worked. The product was known to the trade as the "Huron stone," and a considerable quantity of grind and currier stone grits was quarried and prepared for market. The quality of the product was satisfactory, but the enterprise perished for want of capital. The supply is inexhaustible, as the bed is 25 feet thick.

Going east from Huron the strata rise against the dip at the rate of about eighty feet to the mile, and the bituminous limestone at or below the surface near town, is found at Connelly's hill, two miles east, to have mounted to the summit. Thin outcrops of slaty coal were noted on the sides of the hill; but as these strata are below the proper horizon, the existence of a workable seam is exceedingly improbable if not impossible.

The following section taken on the S. E. qr. Sec. 4, T. 3, R. 2, W., ranges down through the conglomerate and the Chester beds to the upper part of the St. Louis formation.

SECTION ON CONNELLY'S HILL.

Sandy soil with Hematite...........	10 ft.	00 in.
Conglomerate, with stems of fossil plants..................................	45 ft.	00 in.
Bituminous limestone—*Producta, Spirifera, etc*........................	14 ft.	00 in.
Place of rash Coal..................		8 in.
Laminated and shaly sandstone with partings of chert.............	55 ft.	00 in.
Argillaceous limestone containing chert and partings of sandstone..	30 ft.	00 in.
Cherty limestone in cave.............	8 ft.	00 in.
Argillaceous limestone with black flints....................................	6 ft.	00 in.
	168 ft.	8 in.

The flint bed noted, was a favorite resort for the Indians. Here they quarried the material and extensively manufactured arrow and spear points, and other implements. Many ancient fire hearths are seen in the valley adjoining, surrounded with heaps of "flint chips." Mounds on the top and eastern face of the hill indicate the presence of an earlier race.

CONNELLY'S CAVE

Has its door at the foot of the hill, Section 4, Township 3, Range 2, West. Its general course is from northwest to southeast. The roof is usually from 12 to 20 feet above the brook which runs over the floor; the width is about the same but many wide chambers were found, some of which were adorned with snowy curtains of stone supported by robust stalactites and spherical stalagmites. It has an explored length of two miles. Much nitrous earth, spangled with shining crystals, is found in the upper part. A bed of pure yellow clay, ready washed, invites experiments by potters. The cave was formerly frequented by the black bear whose wallows and winter beds may be seen. For a list of the actual fauna, I am indebted to Dr. Elrod, of

Orleans, viz: A Fly, Beetles, Crickets, Centipedes, Crawfish, Blind-fish, etc. including several new species. The blind animals are permanent residents of the cave. A large headed "seeing fish," *Potamocottus?* winters in the cave, but goes out at the breeding season to the light and sunshine of summer.

"Spice Valley" in which Bryantsville is situated, gives name to the civil township. It was originally a dark gloomy forest. Giant walnut and poplar trees towered above, while a tangled mass of tree-like shrubs as Wahoo, Spicewood, etc., crowded the surface. Now cultivated, good crops of corn and wheat are raised. The "Old Kentucky" settlers have given much attention to the cultivation of the grasses, and several good *bluegrass* pastures are the result. This valley once had an outlet to White river, but the mouth is now silted up by a sand and gravel bank of great hight. Beds of sand are noted on the old Bryant farm 225 teet above the present river. Near the residence of Wm. Bryant, southwest quarter Section 13, T. 4, R. 2, W, a small crevice pierces the roof of an unexplored cave; rocks thrown in may be heard for several seconds leaping and crashing down the black abyss. A stone attached to a string wandered 125 feet toward the bottom of the cave. Just below stump-hole-ford the "Buzzard" or "Saltpeter cave" is known to contain apartments on two floors. On Isaac Kerns' land, northwest quarter Section 12, T. 4, R. 2, W., a steep bluff exposing nearly the whole depth of the St.Louis beds occurs: along the crest of the bluff may be seen numerous specimens of *Lithostrotion proliferum*, sometimes in tufts, but generally the calyces are solitary.

Blue Spring cave on the south side of White river, and two miles below Wood's ferry, has been explored three miles. A large stream of water runs out, which is said to have cut basins within the cavern to a depth of more than 100 measured feet; the volume is greatly increased by rains, or at time of high water, and then its current may be seen sweeping across the river into which it is discharged. It would be interesting to discover the source of this greatly

increased amount of water, whether from "sinks" and branches, or from the river itself at a higher level.

Mitchell, a thriving railroad town, is situated at the crossing of the O. and M. with the L. and C. railway. The purposed road hence to the Ohio river at Rockport, fairly promises completion at an early day, and traversing, as it does, the coal fields of Dubois and Spencer counties, will give incentive to manufactures by furnishing cheap fuel. The town is surrounded by a wide area of level or gently undulating land which, judging from the surrounding hills, was originally a valley of erosion, and afterwards the flood plain of White river. The surface rock is the upper cherty member of the St. Louis beds. At every wash, around town, massive specimens of silicified corals as *Lithostrotion Canadense*, *L. proliferum*, and *Syringopora* are found with quantities of *Productus cora*, *Bellerophon levis*, *Dentalium primevum*, *Athyris ambigua*, etc. Sink holes are a constant feature, some forming pools of water—ready-made fish ponds—while others are dry, and some of which, shaded by surrounding trees, might be utilized as amphitheaters for lecture or festive meetings. Many wells in this region are fed by the underground brooks, and from these it is not unusual to draw up eyeless fishes and crustaceans, inhabitants of the adjoining caves. The "valley level" is bounded on the west by a range of hills composed of the Chester formation, running from northwest to southeast nearly parallel with, and about three miles west of the L. and C. R. R. From the top of one of these hills, on the Rariden farm, Sec. 26, T. 4, R. 1, W., one hundred and seventy-five feet above the plain, is obtained a good view of the surrounding country, including the conglomerate hills, six miles to the northwest; Bedford, eight miles to the northeast; the knobs of Washington and Jackson counties ten or fifteen miles away in the eastern horizon, with glimpses of White river and its valley. The broad alluvial plain within this area of more than one hundred and fifty square miles, is a measure of the duration and extent of past erosive forces.

The following section, taken at Peach Orchard Hill, Sec. 26, T. 4, R. 1, W., shows the extent of the Chester rocks at this point. Many interesting fossils, including perfect specimens of *Lepidodendra*, *Stigmaria* and *Sigillaria* were collected here by Miss Lottie Rariden:

SECTION AT RARIDEN'S HILL.

Slope, sand and clay....................	40 ft. 00 in.
Sandstone, ferruginous, laminated, with trunks and bark of carboniferous plants and thin partings of coal....................................	60 ft. 00 in.
Argillaceous limestone with Chester fossils, the upper bands lithographic	35 ft. 00 in.
Chert beds with siliceous corals......	40 ft. 00 in.
	— —
	175 ft. 00 in.

The proprietors of these elevated tables have taken advantage of the immunity from frost, afforded by sharp knolls, and devoted a large area to the cultivation of fruit with profit. In fact, persons who plant a few acres of such land, are at once placed in easy circumstances, with a source of income more reliable than mines of gold or coal.

Dr. Rariden, W. Dodson, John Edwards and others, have given the culture of fruit much attention. The area planted to peaches amounts to over one hundred acres, of which fifty acres are in full bearing. The average crop of peaches nets $100 per acre. Mr. Dodson sold his crop of 1871 in the orchard for $200 per acre. Vineyards of small extent are planted, with cheering prospects. The Ives seedling and Concord vines are thrifty, sure and prolific bearers; they are said to have never been affected by the "blight" in this vicinity.

In the road, near the residence of J. L. Dodson, S. W. qr. Sec. 26, T. 4, R. 1 W., is a coral reef—silicified *Syringopora*, in a matrix of chert. Blocks of this were quarried and used by the prehistoric races to make the reddish

colored wrought stone weapons, so often found in this vicinity. A weathered specimen of this coral was presented to the State Cabinet by Capt. R. P. Dodson, of exceeding beauty. Another, and masses of *Lithostrotion* were donated by Dr. J. W. Harbin. On the Dodson farm was found a sumach (*Rhus Glabra*) of prodigious size, the trunk measuring eighten inches in circumference.

"Mitchell lime" is favorably known to the trade. Asa Erwin, on Rock Lick creek, N. E. qr. Sec. 24, T. 4, R. 1 W., uses a common kiln, capable of burning one thousand bushels at a time. His annual product is seventeen thousand five hundred bushels, which sells at twenty cents per bushel delivered on the cars. The product is a white lime, which works "hot," and is found to be nearly equal to cement for foundations. He makes use of the *Vermicular* stratum, a bluish gray limestone, massive, but traversed in every direction irregularly by tubular canals, from one-eighth to one-half inch in diameter. The stone, on account of its porous nature, is found to burn and slake with great certainty. The waste lime from this kiln has been used with remarkable profit as a manure, and the result invites further experiment.

SECTION AT ERWIN'S KILN.

Soil and slope, broken chert.........	3 ft.	00 in.
Slaty coal.................................		4 in.
Argil. limestone.........................	2 ft.	6 in.
Argil. limestone, lithographic........	1 ft.	2 in.
White or gray limestone...............	3 ft.	6 in.
Vermicular limestone..................	4 ft.	6 in.
Heavy bedded limestone...............	6 ft.	00 in.
Flaggy limestone........................	8 ft.	00 in.
	29 ft.	00 in.

The adjoining cave was formerly resorted to by black bears for hibernation. Bones and teeth of these animals are often found in the cave, and occasionally flint spear and arrow points, showing that our predecessors fought this

animal in his den. Rock Lick creek flows from the cave, crosses the circular "sink valley," and passes away under the hill on which the lime kiln is situated, to emerge in another valley beyond, playing "hide and seek" amongst the rocks.

In the neighborhood, Maj. D. Kelly and Jno. Tomlinson burn stone from the same geological horizon. Their annual product is about 10,000 bushels. The lime is popular and in demand for shipment to the lower Wabash and southern Illinois.

Near the residence of J. H. Crawford, S. W. qr., Sec. 18, T. 4, R. 1 E., is a good exposure of the upper St. Louis beds, rich in fossils—*Pentremites conoideus* and *P. Woodmani* were especially abundant. Going east from Mitchell, outcrops of the chert bed are seen along the hillsides and railroad cuts. Fossils are abundant, consisting of forms characteristic of the St. Louis limestone. At the top of the hill near Hamer's mill, the only *perfect* specimen of *Zaphrentis spinulosa* found in the county was picked up and presented by Dr. McIntyre.

HAMER'S CAVE

Is entered on the side of a hill, southeast quarter Sec. 32, T. 4, R. 1 E., 45 feet above the valley. A main and narrow side entrance, both handsomely arched, give admittance. The floor is level, six feet wide and covered with a swift stream of water eight inches deep, although at places the depth is increased to twenty feet. A boat of course is needed for exploration. Three quarters of a mile from the door is the first fall. The whole stream rushes down an incline only three feet wide, with great violence and a noise that fills the cave. The boat must be carried above this obstacle, when another voyage is taken along a space of 300 feet to the second falls, or "grand cascade." Beyond, the cave is low, wet, and full of rushing water, which flows out of a crevice in the rock. Eyeless fish, crawfish and other crustaceans are caught in this and the two adjoining caves, which have outlets in the grand amphitheater in which the mill is situated. The cave creek,

applied to a wheel 22 feet in diameter, affords a power equal to nine horses. By using unemployed facilities this power may be quadrupled.

DONNELSON'S CAVE.

Donnelson's cave has its entrance on S. W. qr. Sec. 33, T. 4, R. 1 E, near "Shawnee Cottage," the winter residence of Mr. George Donnelson. A large stream of water is discharged which was used by the former proprietor to drive a woolen, grist and saw mill. About the year 1800 gunpowder was here made from the great supply of nitrous earth found in the upper chambers. Remains of the powder mill may still be seen. The entrance to the cave is wide and lofty, but following the central passway it is soon reduced to a narrow passage, covered with a shallow stream of water. Explorations may be made by wading or in a light canoe. Within is a magnificent cascade, where the stream rushes and leaps down a narrow passage with such violence that the rumbling noise is heard at the entrance. This passway is known to extend through to Dalton's spring, three-fourths of a mile to E. S. E. Near the entrance a dry cave is seen opening to the east; directly opposite a lofty corridor leads to the west, and in less than one hundred feet enters a grand hall twelve feet high, three hundred feet long and forty feet wide. If lighted this would make a novel and interesting lecture or assembly room. In the winter thousands of bats gather here to hibernate, hanging in clusters, like a swarm of bees, from the ceiling or sides. The clusters of bats vary in numbers from twenty to several hundred, or in measure "from a quart to a bushel."

Eyeless fishes, crustaceans and crickets have been caught here. The cave shows signs of pre-historic inhabitants, as flints, stone axes and bones have been found in and around the door of the cave in numbers. I append a list of animals found in Connelley's, Hamer's and Donnelson's caves, by Drs. Elrod and Sloan; insects and fishes as determined by A. S. Packard and Prof. Cope. (See Geol. Ind. 1872, and report of trustees of Peabody Academy, 1872.)

CAVE FISHES.

Amblyopsis speleus..............................Blind.

CAVE CRUSTACEANS.

(*Crawfishes, etc.*)

Cambarus pellucidus..............................Blind.
Cæcidotea stygia..................................Blind.
Crangonyx vitreus................................Blind.
Euphilosia Elrodii................................Blind.
Cauloxenus stygeus..............................Blind.

CAVE INSECTS.

Anthomyia (?)......................................Blind.
Anopthalmus tenuis..............................Blind.
Platynus marginatus.............................Seeing.
Ceuthophilus Sloanii.................... ....Seeing.

At the Mill creek quarry cut, of the O. & M. R. R., five miles east of Mitchell, is an interesting outcrop, showing the junction of the St. Louis with the Keokuk. The first is rich in characteristic fossils, including many *Pentremites;* in the latter was found a tooth of a shark, *Cladodus spinosus.* A bed of ochreous clay, of a rich brown color, in sufficient quantity to paint all the railway cars and agricultural implements in the world, covers the rocks, and ought to be utilized. Ochre is common and in unlimited quantities all over the county.

From this point eastwardly the Keokuk beds generally constitute the surface rock along the railroad. They are seen rapidly mounting the sides of the hills, and near Tunnelton form the cap rock, one hundred and fifty feet above the river.

SECTION NEAR TUNNELTON.

Slope......................................	
White limestone..........................	2 ft. 00 in.
Blue limestone............................	6 ft. 00 in.

20

Argillite with geodes	5 ft. 00 in.
Magnesian limestone with *Hemipronites crenistria* etc.	6 ft. 00 in.
Argillite with geodes.....................	12 ft. 00 in.
Green and blue shales.....................	20 ft. 00 in.
Silicious shales with bands of Waverly sandstone................................	30 ft. 00 in.
Knobstone shales, containing *Producta and Spinfer capax*......................	60 ft. 00 in.
	141 ft. 00 in.

Outliers of the Keokuk beds are seen on the hill tops about Ft. Ritner. In the bed of the creek north of the village, an immense number of geodes, some of great size were seen. The Knobstone forms the sides of the valley; but very few imperfect fossils were found. The sandstone in this vicinity and at Tunnelton, although not extensive, is of excellant quality, and may be sawed or split. Well cut samples were seen at the residence ofthe "Section master" near the lower tunnel. The greatest exposure of the Knobstone shales in this vicinity measures 250 feet above White river.

The crests of the Knobs have been devoted to fruit culture. Extensive orchards and vineyards have been planted with good results. The crop is sure, of good quality, and commands a ready market. Nature declares that for long periods in the past, these knobs have been protected by their peculiar structure from the effects of sudden "cold snaps," for on such high knolls, chestnut trees three to four feet in diameter are growing, vigorous and fruitful. These trees cannot bear fruit, can hardly live in the cold temperature of the valleys. The same fact was noted as to the high hills near Port Williams in the west side of the county.

At Leesville the soil is of rich, reddish brown, fading to a "mulatto loam," and would doubtless produce good tobacco as well as corn, grass and wheat. The surface rock is the Keokuk with outliers of St. Louis Limestone. The

creek valleys are cut down some depth into the Knobstone shales.

At Heltonsville is a good illustration of the uneven surface of the Knobstone, on which the more recent limestones were deposited. In the south part of the village the Knobstone exposes a thickness of over 90 feet, but dipping rapidly to the north and west passes below the water of Leatherwood in that part of the town. Heltonsville is famous on account of the number, variety and beauty of the geodes here found. Many of them are geodized *Crinoidae*, *Spirifera*, *Zaphrentes*, *Lithostrotion*, *Goniatites*, *Bellerophon*, etc.

SECTION SOUTH OF HELTONSVILLE.

Clay and geodes on slope..............		
Soft Knobstone........................	50 ft.	00 in.
Green and blue pyritous shale........	40 ft.	00 in.
	—	—
	90 ft	00 in.

SECTION NORTH OF HELTONSVILLE.

(West side of Leatherwood Creek.)

Slope....................................		
Geode bed..............................	4 ft.	00 in.
Crinoidal limestone crowded with joints, plates and crushed heads of *Encrinites*...........................	8 ft.	00 in.
Knobstone shale and sandstone to creek..................................	15 ft.	00 in.
	—	—
	27 ft.	00 in.

A syclinal axis a mile north of town depresses the strata sufficient to allow outliers of St. Louis limestone, which are quarried for masonry and burning.

Guthrie is surrounded by high Knobstone hills capped with Keokuk limestone. Immense numbers of geodes varying from one to fourteen inches in diameter, are found

along the creeks and hill sides. Quarries of Waverly sandstone (Upper Knobstone), are of common occurence; used for foundation and chimneys this stone presents a good appearance, weathers well, and invites exploration by parties desiring a sandstone which may be cut by sawing. The only Knob-fossil seen was a *Spirifer capax,* found on the roadside a mile east of town. The bottoms of Salt creek in this vicinity are of great width—entirely out of proportion to the necessities of the actual stream, and evidently owe their existance to causes anterior to the present state of affairs and not now in action. Large amounts of oak and poplar lumber, staves etc., are manufactured and shipped from this and neighboring stations. The knobstone soil is well suited to the growth of the fine grasses. Fair crops of corn and oats are produced, and plants that require a large amount potash as potatoes, turnips, etc., are of unrivalled quality. The knob shales contain much pyrite (Sulphuret of Iron) which decomposes on exposure. The sulphurous exhalations from this source are supposed to prevent blight and the growth of fungi on fruit trees and vines.

SECTION NEAR GUTHRIE.

	(west of town.)		(east of town.)
St. Louis limestone..	40 ft. 00 in.	to	00 ft. 00 in.
Keokuk limestone...	25 ft. 00 in.	to	3 ft. 00 in.
Knobstone...........	50 ft. 00 in.	to	140 ft. 00 in.
			145 ft. 00 in.

From a well dug by O. P. Anderson S. W. ¼ Sec. 15, T. 6, R. 1 W., the following St. Louis fossils were identified, viz: *Rotalia, Cypris, Euomphalus, Bellerophon, Fenestella, Zaphrentis, Terebratula, Rhynchonella, Spirifera, Murchisonia, Pentremites,* and *Batocrinus.*

West of Guthrie the soil indicates a natural adaptation for the growth of grasses. This indication may be followed with profit. Some good fields of blue grass were noted.

ECONOMIC GEOLOGY.

Agriculture is the chief source of a people's wealth. The quality of the different soils has been mentioned in the foregoing notes. About one-half of the land in Lawrence county has been reduced to cultivation; the oth. r half is unimproved, and devoted chiefly to the production of brush, weeds and briers. I cannot too earnestly recommend that such lands ought to be improved by destroying the useless growth, and seeding to grass. Experience demonstrates that grazing is one of the most profitable branches of agriculture. Limestone is abundant, and may be burned by farmers at a low cost per bushel. The tests made by Messrs. Hall and Irwin show that worn fields may have their fertility restored and cheaply maintained by the use of lime.

WATER POWER.

This power is the cheapest known. The expense of a dam rarely exceeds the cost of engines and fixtures. The motive power of such a stream as White river, if utilized, is of great value. It is now allowed to flow away without let or hindrance. In New England such advantages would call into existence large manufacturing cities; and we may expect the same results here. A large amount of this power may be profitably applied to the preparation of stone for architectural purposes, or for metalling turnpikes.

STONE.

This county is well supplied with building material. The "Bedford stone" i so well known, that its excellence is proverbial. Similar beds exist in different parts of the county. We may surely look to these as a great source of wealth. With capital, energy, and the use of water power,

the market demand of several States could be easily supplied. The sandstones in the eastern and western parts are of fair to good quality. The fire and weather proof conglomerates are superior for foundations and heavy masonry. Sand, lime and clay, for bricks, are abundant.

The limestones throughout the county, broken in fragments, are well suited for metalling turnpikes; and enough to supply the county and adjacent regions could be cheaply prepared by machinery, recently invented for that purpose.

IRON ORE.

The Fayetteville ore is of unrivaled quality, and from tests made at Whittaker's farm is well developed. Careful examinations will discover similar deposits in neighboring localities. Small specimens of excellent ore were found near Bartlettsville, the amount of which has not been tested.

SILVER.

Indian tradition has located one or more mines of silver or lead in every township between the Alleghany and Rocky mountains. In this county they were more liberal, and in fancy gave beds of silver to almost every farm. No evidence to support such ideas was found, and the existence of workable quantities of silver or lead is highly improbable if not impossible.

MINERAL SPRINGS.

The White Sulphur springs noticed at Avoca, Bedford and Indian creek, have a well ascertained value for medical purposes, and may be relied on to cure or relieve our "national disease," dyspepsia.

CAVERNS.

The caves of this county are extensive, generally unmutilated and full of interesting forms and life. They will command the attention of tourists and naturalists.

ANTIQUITIES.

On the southeastern slope of the hill over Connelley's cave, two miles east of Huron, is a group of seven mounds,

from two to four feet high, and an obscure winding way may be traced leading from the cave spring to the top of the hill. On the summit fragments of sandstone reddened by burning, and small shell heaps are seen. The mounds were probably habitations. From protruding pieces of stone seen on the sides, the internal construction was of that material instead of timber, as was usual in similar structures on the Wabash and Mississippi. A central tumulus having a double circular wall was probably for sepulchral purposes.

A mound similar to the last at the site of the former county seat, Palestine, or "Old Palestine" as it is called, was explored in 1870 by Messrs. Newland, Dodd and Houston. On the surface of the hill a confused mass of stones, such as a man could conveniently carry, were noticed, indicating a circular wall twenty feet in diameter. It was found to be a vaulted tomb. The first or upper vault, contained the bones of many women and children, a layer of flat stones divided this from the second, which contained the bones of men; another layer of flags, and at the bottom, six feet below the surface, two skeletons were found, with their heads placed to the east and faces to the north. The last were persons of great size, being not less than six and a halt feet high. With the skeletons were found a quantity of flints, arrow points, etc.; near the head of the largest individual a pair of hammered copper ear rings and a globular "war whistle:" The keen noise of the latter may be compared to the sound of a policeman's whistle, and can be heard nearly a mile. Stone axes and pieces of pottery are found on the surface near this tomb. Mr. Bart. Williams has a collection of stone relics, consisting of axes, flints, pestles and two carved pipes, one modeled after the head of an Indian, with strongly characteristic features, the other of a deer, both well executed.

Acknowledgements are due to the citizens of Lawrence county for courtesy and polite aid. Thanks are returned to the following persons for special favors and specimens presented to the cabinet:

Charles T. Woolfolk, I. W. Thomas, Theo. Aley, Eddie

Culbertson, Drs. Newland, Gardner and Stilson, Hon. G. W. Friedly, Thos. Dodd and H. and G. Houston at Bedford; to Col. J. E. Bryant, Dr. Johnson and J. and B. Williams, at Fayetteville; to Lafe. Prosser and J. Marley at Huron; to Dr. McIntire, Capt. Dodson, Hon. Wm. H. Edwards and Messrs. Hamer, at Mitchell; T. J. Reed, at Fort Ritner; Mr. Starr, Heltonsville; and Capt. W. and O. P. Anderson, at Guthrie.

NOTE.—Since the following pages were written I have learned that the BEDFORD STONE, of Lawrence county, Indiana, is exclusively used in constructing the exposed surfaces, pilasters and capitals in the new State House at Springfield, Illinois.

After a carefully conducted series of competitive tests, by experts, this stone was deemed superior to any other in the Western States for permanent, heavy structures where ornamentation is desired. Some of the capitals have been elaborately wrought at a cost, for labor, of eight hundred dollars each, and attest the superiority of this stone for carved work.

ANALYSES OF IRON ORES.

BY E. T. COX.

Hydrated brown oxide of iron from George Whitaker's land, Sec. 28, T. 5, R. 2, leased by the Shoals Iron Company, brownish red color, fine grained and free from chert.

No. 1 was sent from the Shoals blast furnace, Martin county Indiana.

No. 2, direct from George Whitaker.

Analysis of No. 1:

Loss by ignition, water	13.000
Insoluble silicates	.900
Ferric oxide	84.890
Alumina	trace
Phosphoric acid	.145
Manganese	none
Magnesia	none
Carbonate of lime	1.000
Loss	.065
	100.000

Metallic iron, 59.423.

Analysis of No. 2:

Loss by ignition, water	13.000
Ferric oxide	83.200
Alumina	trace
Insoluble silicates	1.200
Phosphoric acid	.150
Sulphur	trace
Carbonate of lime	2.000
Manganese	none
Loss	.450

Metallic iron, 58.24.

This ore is rich in iron, containing from 58.24 to 59.423 per cent., and remarkably free from earth and deleterious impurities. It will, with proper treatment, make a very fine quality of metal, suitable for Bessemer and other uses. The Shoals Furnace Company have commenced to use it and expect to obtain their entire supply of ore from this county.

"PYRAMID MOUND"
near Vincennes, Knox Co., Ind.

GEOLOGY

OF

KNOX COUNTY.

BY JOHN COLLETT.

This large and fertile county is situated well to the southwestern part of the State. Vincennes, the county seat, being 120 miles southwest from Indianapolis. Enclosed on three sides by the Wabash and White rivers, it is bounded on the north by Sullivan and Green, east by Daviess, south by Pike and Gibson counties and on the west by the State of Illinois. The superficial area is 540 sections or square miles. Several creeks and small streams, as Marie, Deshee and Pond creek and their affluents ramify into all parts affording some eligible sites for mills, and an abundance of water for stock and other purposes. Bottoms from one to three miles wide extend along the Wabash and White rivers, of remarkable fertility. These were originally to a small extent prairies, but as a rule were clothed with a thick growth of Walnut, Hackberry, Cottonwood, Sycamore, Oak, Cypress, Catalpa, Gum, Coffee nut and Mulberry, of largest size. Bordering these bottoms on their outer side, are higher benches and terraces built up with gravel

and fluviatil drift, from five to thirty feet above the low bottoms, former flood plains of the river.

An elevated ridge cut through by Marie creek, "Old river" and Deshee creek, extends from north to south through the central parts. The surface of this is covered with "Lacustral" loams, capped by a bed of sand from ten to forty feet in thickness upon the highest part of the divide, and was originally clothed with a forest of Poplar, Oak, Hickory, Maple, Gum, Ash, etc. The ridge is traversed or pierced by several marshes and ponds, as are also the first and terrace bottoms, which on examination prove to be old river beds.

The geological formations of this county comprise three opochs of the Quaternary, and the upper division of the coal measures.

SURFACE GEOLOGY.

A cut commencing at the top of the highest ridge and extending to the rocky bottom of the river valleys, in fact laying bare the stone skeleton of the county, will give a full section of the recent or quaternary deposits. Such a section gathered in detail from a variety of sources is here brought together.

GENERAL SECTION OF SURFACE DEPOSITS.

Recent alluvium "bottoms."	10 ft. to 40 ft. 00 in.
Terrace banks	5 ft. to 30 ft. 00 in.
Ancient "sandbars" on sides and top of highest ridges	150 ft. to 30 ft. 00 in.
Lacustral silt or "Erie clay"	5 ft. to 170 ft. 00 in.
Loess—Lacustral	5 ft. to 40 ft. 00 in.
Glacial Drift	5 ft. to 0 ft. 00 in.
Excavations during the Glacial Epoch which constitute the valleys of the Wabash, White river, etc., extending about 100 feet below the present low water mark of the streams	300 ft. 00 in

The time and precedence of these beds is known from the order of their occurence, which is invariable. The alluvial "bottoms" along the streams originating from the ordinary floods, are made up of sands and clays spread out by over-

flow, and rest upon or *against the sides* of the gravel terraces. The terraces are consequently next in age and rest upon or against the sides of the more ancient alluvium or "sand hills;" these in turn are more recent than the Loess clays, which superimpose the true Boulder or Glacial drift.

For a more full description of these beds and the *mode* of their occurence, the reader is referred to report on the geology of Sullivan and Lawrence counties; to Prof. Newberry's report, Geology of Ohio, and Prof. Swallow's Physical Geography of Missouri. From these papers it will be seen, that at or about the close of the Glacial epoch, a powerful current of water swept under or from an icebelt reaching south of central Indiana, which by its great violence cut deep channels in the solid rocks in its southward course. This was succeeded by great lakes extending over and beyond southern Indiana and Illinois, whose low water line was at least 200 feet above the highest hills in the county. At this time the Loess or "Lacustral" * clays were deposited in the shallows of that lake, as at Freelandsville, from Bruceville south, etc., and at the same time the deep gashed channels were silted up with the unctuous clays filled with vegetable matter, known as "Noah's cattle yard," which is so constantly met in shafts and bores about Sandborn and elsewhere.

The river valleys were silted or built up at least 80 or 100 feet above the present water line, for we find, on the divide separating the Wabash and White rivers at this level, ancient river channels now marshes, ancient bars now gravel banks, ancient thoroughfares now brooks. A thoroughfare or channel leading from White river near Edwardsport to the Wabash above Vincennes, would require a ditch of but little depth † to unite the high waters of the two rivers.

* A name suggested Prof. C. .A White as a better term than "Bluff" or "Loess."

† Estimated at fifteen feet.

When the great Southern lake commenced emptying to the south—a slow long process,—the Wabash and White rivers began to run with an easy lifeless current, at times indifferently traversing all the region on either side and between the two, and at the eddy line between or outside of their currents depositing the heavy beds of sand found along the high hills on either side of each river. This theory is sustained as to the Wabash by the fact, that in washes on the highest sand hills in the county fine grains of magnetic iron ore of northern origin were noticed, which from the accompanying material had been sorted from the upper river drift, and was considered notice that the Wabash had been there; as to White river by the fact that geodes and other sub-carboniferous fossils, rocks and clays are found all over this region and along the bluffs north of Vincennes, some of which were characteristic of Lawrence and Brown counties, and do not occur on the upper Wabash, and show conclusively that at one time White river had discharge into the former by Marie creek.

The upland division of the county presents a notable variety of soils, none of which owe their origin to the pulverization of the local rocks, but instead are imported by drift action from regions more or less remote. The post-oak lands at Freelandsville, and the ash gray "clay loams" characterized by a growth of Persimmon, Gum trees, etc., are compact impalpable sands, impervious to air and water, and subject to great vicissitudes as to drought or moisture. They are as before said of lacustral origin. Another very considerable part of this area is characterized by a growth of Poplar, Walnut, Sugar, Ash, etc., and blue grass: this soil is yellow or of a reddish brown color—the color alone would indicate its origin to be the feriferous rocks of the sub-carboniferous limestones, but in addition fossils of that formation are so frequently found as to fully settle the question, and prove conclusively that these soils and their fossiliferous pebbles were brought here by the current of a river flowing at a level much above the channel of any of the present water courses, and whose head waters were then

engaged in cutting beds in the sub-carboniferous limestones, from 50 to 80 miles to east and northeast.

Still above and well up to the summit of the high—although not the highest hills in the county—are the old sand bars or high water line of these ancient rivers. This soil is not considered first-rate in an agricultural point of view, yet from the elevated position and warmth of these sands, they have been found to be well adapted to the growth of grapes, peaches, pears and other tender fruits. and hence are of great value. Further mention of the soils and their product is made under the head of Economical Geology.

PALEOZOIC GEOLOGY.

The rocky formations of this county comprise the upper part of the coal measures, from coal K to the highest coals of the Indiana and Illinois coal basin, including the soft, coarse ferruginous sandstone, known as the "Merom rock," so well developed at Ft. Knox and other parts of the county.* The principal accessible outcrops are along the bluff's of the Wabash and White river, the intervening region being covered to a great extent with drift and alluvial soils.

The following connected section presents a general view of the accessible strata gathered from isolated stations:

*This sandstone, for the present, is still included in the coal measures, although its lithological character and position indicates a more recent origin.

CONNECTED SECTION—KNOX COUNTY.

1. Soil and drift...........	
2. Red and white soft ferriferous sandstone,—"Merom"-Ft. Knox Rock	30 ft. to 80 ft. 00 in.
3. Shale and "clod"......	2 ft. to 8 ft. 00 in.
4. Bituminous limestone..	0 ft. to 3 ft. 00 in.
5. Black coaly slate........	1 ft. to 4 ft. 00 in.
6. *Rash coal*................	2 in. to 3 ft. 00 in.
7. Fire clay..................	2 ft. 00 in.
8. Flaggy sandstone with plates of limestone......	5 ft. to 23 ft. 00 in.
9. Argillaceous or bituminous limestone........	4 ft. to 6 ft. 00 in.
10. Black slate and Cannel coal..................	1 ft. to 3 ft. 00 in.
11. *Caking Coal N?*......	2 in. to 1 ft. 06 in.
12. Fire Clay................	2 ft. 06 in.
13. Gray argillaceous flaggy sandstone, changing to limestone in bores along the Wabash river	30 ft. to 80 ft. 00 in.
14. Yellow quarry sandstone......................	4 ft. to 23 ft. 00 in.
15. *Coal M*, fat caking...	2 ft. to 4 ft. 06 in.
16. Fire clay.................	1 ft. to 4 ft. 06 in.
17. Gray sandy shales or hardened soapstone, changing to limestone, in bores near the Wabash	21 ft. to 35 ft. 06 in.

18. Soft black slate, (local) or soapstone............	08 in.
19. *Coal L*, white ash, caking	4 in. to 4 ft. 07 in.
20. Fire clay	4 ft. 06 in.
21. Brown sandstone and silicious shale...........	10 ft. to 17 ft. 4 in.
22. Hard bituminous limestone, full of fossils.....	3 ft. to 5 ft. 01 in.
23. Calcareous and pyritous "clod"............	3 in. to 2 ft. 00 in.
24. Black, sheety slate, with fossils..............	5 ft. to 1 ft 06 in.
25. *Coal K* caking or laminated....................	3 ft. to 6 ft. 06 in.
26. Fire clay.................	7 ft. to 4 ft. 00 in.
27. Flaggy sandstone and shales.....................	6 ft. 00in.
28. Clay iron stones and shales.....................	12 ft. to 16 ft. 00 in.
29. Dark shale, with sulphur balls..............	4 ft. to 9 ft. 04 in.
30. Black sheety slate, and Cannel coal ?...........	1 ft. to 3 ft. 00 in.
31. *Coal I?* part block...	1 ft. 8 in. to 3 ft. 00 in.
32. Fire clay.................	4 ft. 00 in.
33. Sandstone at bottom of bores.	— —
	350 06

The foregoing section gives an average view of the rocks of Knox county, with the number and relative position ot the explored coals. The spaces and thickness of strata are calculated from the best data available as found at the center and east side of the county. But in passing from the rim of the coal basin in Crawford and Orange across Dubois and Pike counties to the eastern side of Knox, we have seen that the different coals have gradually and irregularly

thickened up from a mere parting to workable seams, and at the same time with equally variable increments the spaces between the coals have been enlarged. We are justified from this to infer that in continuing west toward the deep central part of the basin, the same law will be found to govern, and as a consequence we may expect that along the Wabash river that the *spaces between the coals are doubled* and in some cases quadrupled. Again, the coals and rocks in this county dip from east to west at a rate varying from ten to forty feet, and averaging about twenty-two feet to the mile, with an increasing ratio as we approach the center of the trough in which the valley of the Wabash is situated; all these facts indicate the extreme depth at which we must look for the horizon of the workable coals along the river, where no bores of a sufficient depth have as yet been put down to fully determine their existence or absence. Such a bore is needed to definitely settle the question here hinted at, but the cost will be large, beyond the ordinary limit of private enterprise, and should be carried on under public agencies.

The "Merom"—Fort Knox sandstone, No. 2 of the section, is a prominent feature in the geology of this county and adjoining regions to the north, south and west. It consists of coarse red and white sandstones, the grains or crystals often but little rounded before deposition, slightly aglutinated with iron, so that on exposure the iron is oxidized or rendered soluble in water containing carbonic acid gas; and hence on exposure this stone generally becomes soft or disintegrates to a coarse sand. Sometimes the stone is found to have been subjected to this process by natural causes, where good drainage affords free access to air and moisture, and then the stone is apparently a deposit of coarse white, or yellow sand, so soft that the ordinary pressure of the foot will bury the whole blade of a spade in the quasi rock. A few localities afford exceptions to this rule, as at the upper ledges at Marie creek, in the bottoms west of Wolf's hills, and at Wise's quarry south of Vincennes, where the stone is more compactly cemented, and good

quarry rock is obtained in blocks of considerable size. Typical exposures are seen at the mouth of Marie creek, Fort Knox, Wolf's hills, along the Illinois side of the Wabash from the mouth of Deshee creek to the mouth of White river, at Chimney pier rock, Dixburg hills, and generally along the higher parts of the central ridge it is pierced by wells, some as far east as Freelandsville.

This stone almost continuously forms the high bluffs on either side of the Wabash, but is now separated by a valley from two to twelve miles wide, which contains boldly buttressed hills, disconnected like islands in the level bottoms, as Wolf's, Dubois', Bunker's and Dixburg hills, or sharp cones and solitary pillars, as "La Mamelle" and "Chimney pier Rock." Sections taken at all these points present such uniformity of stratification and composition, that we must conclude that the Merom rock once occupied all the great intermediate area, and that the mighty mass has been eroded by action of water, (save the outliers above mentioned,) the debris carried southward to constitute the "sand barrens" which form such a prominent feature in the surface of the southern part of this, and the adjoining counties to the south and southwest. We may safely conclude that the time necessary to accomplish the removal of a mass of such stone, averaging not less than ten miles in width, and from sixty to one hundred feet in thickness, "was long" and the agency more powerful than the present force of the Wabash. It is known that the valley of this river has been cut out not less than sixty feet below the present low water line. At Vincennes the subterranean river had overhanging sides,* as seen at Fort Knox. This great chasm was afterwards silted up with a black sandy muck, containing many logs, large vines and other vegetable matter, and is often met with in digging wells. When the Wabash became confined to its present

*Mr. Beard informs me that, in digging a well near the center of town, at some distance from the surface he found a soft ferruginous sandstone, and on blasting through about ten feet of solid rock, he found a bed of alluvial sand and water.

water shed, this silt was partially removed, the fine sediment sifted out was carried away by the current, the gravel and stones were left on the bars (terraces) and at the termination of "cut offs." It has been remarked by Ellet and other civil engineers that American rivers flowing from north to south cut their eastern bluff from two to three times more frequently than their western. This is the case with the Wabash, as at "Covington-point-of-Rock," Lodi, the Narrows,* Merom, Fort Knox, etc., and being contrary to the law of gravitation which would create a tendency to the western bluffs, must be accounted for by the fact that at such points the dip of sub-jacent strata are locally reversed, or are fróm west to east.

A characteristic specimen of the eroding force of the ancient Wabash striking its western shore may be seen in the face of the overhanging cliff north of Fort Knox, where deep mouldings and "pot holes" mark the different levels which the river has occupied in past times.

At the base of the Merom rock the exposures generally found in this county, consisted of pyritous shales and "clod," but near Bruceville, and in adjoining regions in Sullivan county, and at outcrops visited in Illinois, this rock is bedded on a conglomeratic limestone, as if a line marking a change of epochs if not of systems.

The rash coals, Nos. 6 and 11, are found pretty constantly near the surface in the western part of the county, as at Oaktown, the mouth of Marie creek, Fort Knox, in White river near Hazelton, and thence to east they rapidly mount the sides to the crest of the hills, and make their final out crops along a line which passes from near Freelandsville by Cox's hill and High Point to the head of Wilson's creek in the southern part of the county. These coals are not of workable thickness, and only serve as a horizon to mark the

*The writer is indebted to the courtesy of the late distinguished civil engineer, Col. W. J. Ball, of Terre Haute, for kindly calling his attention to the inadvertency as to data in this connection in geology of Sullivan county, 1870, page 204.

top of the coal measures, and indicate the depth only at which workable coals may be found. They are generally covered with a black, sheety slate which, containing a large amount of bituminous matter, burns with much flame, and locally affords an impure Cannel coal, but is of little or no economic value.

The limestones, Nos. 4 and 9, superinposing the coals just mentioned, are a more important geological feature than the coals which they accompany. In their usual presentation they are compact, hard, clinky rocks, especially near their outcrop on the east, as north of Freelandsville, at Cox's limekiln, near High Point, and on Wilson's creek; but to west along and across the Wabash in Illinois, they change to soft, laminated beds or calcareous shales filled with magnificent specimens of *Pleurotomaria tabulata*, *P. spherulata*, *Macrocheilus fusiformis*, *M. inabilis*, *Bellerophon carbonarius*, *B. crassus*, *B. Montfortianus*, *Athyris*, *Myalina*, etc., with other fossils heretofore classified as Permian. The flaggy sandstone, No. 8, was not found well exposed, being deeply covered with drift; at adjoining localities as "Shaker quarry," in Sullivan and at Hazelton quarries, it affords flags for paving, and some grits. Calcareous matter increases to the west, and this whole bed is found, in bores, locally changed to limestone. The same remarkable fact, if reports of bores may be relied on, is true of No. 13 of the section.

The yellow sandstone, No. 14, marks the roof of coal M. Where outcrops occur it affords good quarry rock, soft from its bed, but hardening on exposure to the weather, and well suited for foundations and hammered masonry. Examples are noted east of Freelandsville, near Bicknell, and in the southeastern parts of the county.

Coal M. No. 15, of the section, varies from a few inches to over four feet, with an average thickness of about three feet. It is a fat, caking coal, and generally contains considerable sulphur, but at localities the product is known as first-class blacksmith coal, sometimes pure and fat enough to invite the attention of gas companies, and always well

esteemed for grate use. The only openings are at Wheatland and near Bicknell, but the seam has been pierced in wells north of Edwardsport and east of Freelandsville, and from a north and south line drawn through these points, theoretically, the seam underlies the whole region to the west.

The horizon is about the lowest point to which test bores have been put down in the western part of the county. For the remainder of the section we must rely entirely on outcrops and bores along White river.

The space between coals M and L is composed characteristically of sandy shales and soapstone, sometimes hardened into massive argillaceous sandstone. Frequently it is so compact that it has been used for foundations, but from predominance of argillaceous matter it weathers badly, and in a few years disintegrating, becomes clay and sand. Whenever argillaceous material predominates, leaves, stems, and trunks of coal plants are common, especially toward its lower division. In outcrops here observed, the usual fern bed is represented by a soft black soapstone containing much comminuted vegetable matter. Coal L, No. 19, varies from a few inches, in a bore at northeast corner of township No. 5 in range west, to over five feet at Wheatland, and will average more than three feet in thickness. It presents the characteristic features of the seam, and offers a free or semi-caking coal, which burns to a white ash. The product is usually free from sulphur, and compares well with the coals from the same seam at Shelburn in Sullivan county, or Washington in Daviess county. The only openings are at Curry's, and Shepard's new shaft at Edwardsport. A single natural outcrop was observed near low water, in White river, on Donation 135. Theoretically this seam underlies the whole area of the county with the exception of a few valleys around, north, and northeast of Edwardsport, from which it has been eroded. This coal will be found desirable to manufacturers whose business requires a pure free burning fuel, and is of superior quality for locomotive, rolling-mill or engine use.

The bituminous limestone, No. 22, of the section, which so persistently marks the roof-rock of coal K throughout the State, presents all the characteristic features at Edwardsport. In places, it is a compact massive stone, pure enough to burn, or for building purposes, but often changes within a space of five feet to calcareous shale; as was found to be the case in quarrying this stone in the bluff at the latter town. At such stations it is rich in fossils of the following genera, viz: *Producta, Spirifera, Allorisma, Athyris, Hemipronites, Chonetes, Bellerophon, Rhynchonella, Orthoceras, Lophophyllum,* and an undescribed coral, which is probably new to science.

A black, sheety slate, No. 24, succeeds the limestone; rich in bituminous matter, it will generally burn with much flame, and sometimes affords specimens of inferior Cannel coal. It contains scales, spines and dermal plates of the shark *Petrodus occidentalis, Orthocerata, Discina* and *Lingula.* Large boulders, or "pot stones" of pyritized iron ore are found in the lower division of this slate, some of which are eccentric in form, others of great size and weight, become an incumbrance to the proprietor.

Coal K. No. 25 of the section is the lowest surface outcrop seen in the county. It measures about three feet in the vicinity of Sandborn where it is laminated in structure and partly block. At Edwardsport it varies from three to five and a half feet, with an average thickness of nearly four feet; thence dipping south as well as west with sharp undulations, it passes below the surface of white river, just rising to low water mark at the mouth of Indian creek, and is pierced by bores north of Wheatland. At Wilson's shaft in Daviess county five miles east of Wheatland, and at Dr. Posey's bank near the southeast corner of the county, this seam is grandly developed, measuring at the former full *seven feet,* and at the latter bank *ten feet* in thickness. These facts indicate a persistent thick seam, and we may safely expect to find it underlying the eastern and central parts of the county; a source of wealth greater and better than mines of gold or silver. The product is usually a

strong fat caking coal, occasionally sulphurous, but well esteemed for grate and engine use. By reason of the great thickness of the seam this coal may be cheaply *mined*; and cheaply crushed and washed, by power obtained from White river; thus offering remarkable facilities for the manufacture of cheap coke on a large scale.

The strata below K represent the place of the Block coal seams, and have only been explored by bores put down in the vicinity of Sandborn, for full particulars of which I refer to local details at that town. The borings which came from coal I? No. 31 of the section, were a mixture of block and cannel coal. A shaft at this place was in progress at the time of my visit, the result of which I am not advised. The existance of a workable seam at this horizon is possible but not exceedingly probable.

The foregoing gives a general view of the geological structure, coals, and stone of the county, to which will be added represenative sections and notes of details for local information.

LOCAL DETAILS.

Commencing at the northwest part of the county, a well dug by Hon. J. Alsop just north of Griswold, in the south part of Sec. 33, T. 6, R. 9, pierced at a depth of 43 feet the upper rash coal. The horizon is further indicated by the occurrence of the lower or ferruginous beds of the Merom rock below the surface in this vicinity. Bores put down at Paxton and Carlisle a few miles north in Sullivan county, found the lower coals well developed, apparently of superior quality, and we may expect to find them equally well developed in this part of Knox county. The section of the well at Carlisle throws much light on the geology of this county, and is added. It was bored in the months of April and May 1873, for Messrs. Alsop, Hills, Helm and Whipps, by Mr. Wm. Adams, to whom I am indebted for information.

SECTION IN CARLISLE WELL.

Surface clay	24 ft.	00 in.
Red sandrock	4 ft.	00 in.
Fire clay	1 ft.	7 in.
Siliceous soapstone	2 ft.	6 in.
Soapstone and flaggy sandstone	30 ft.	3 in.
Gray Shale	12 ft.	00 in.
Calcareous shale	8 it.	00 in.
Coal	00 ft.	7 in.
Fire clay	2 ft.	0 in.
White limestone	20 ft.	0 in.
Soft gray limestone	36 ft.	3 in.
Fire clay	4 ft.	00 in.
Sandstone	1 ft.	00 in.

Black slate	00 ft.	6 in.
Hard gray limestone	26 ft.	11 in.
Gray shale	15 ft.	2 in.
Fire clay	6 ft.	3 in.
Sandstone	1 ft.	00 in.
Coal M	3 ft.	1 in.
Fire clay	5 ft.	00 in.
Limestone	5 ft.	00 in.
Parting		
Limestone	5 ft.	00 in.
Parting		
Limestone	4 ft.	00 in.
Parting		
Limestone	8 ft.	00 in.
Gray shale and soapstone	12 ft.	1 in.
Coal L	6 ft.	4 in
Fire clay	5 ft.	00 in.
Gray flinty limestone very hard to bottom	5 ft.	00 in.
	254 ft	06 in.

The well was bored with a hollow drill, and gas pipes for poles, affording an excellent opportunity for accurately determining the quality and thickness of strata. The coal was brought up in cubes from a quarter to half an inch square; compact, glossy, and to the eye, of superior quality: that from M, was a fat caking coal affording much gas: that from the lower seam L was more laminated, indicating a semi-caking white ash coal.

It will be observed that the double limestone so constantly marking the space between coals L and M in Sullivan county, is here divided by partings half to an inch deep, and is thickened by the addition of one or more bands. This last feature is typical of the new and unexpected developement of calcareous rocks found in all the bores along the Wabash, from this for sixty miles south, attaining its maximum development near the mouth of

White river. Limestone is supposed to be deposited in clear water. The animals (Bryozoans, Crinoids and Corals), of which it is principally composed, cannot exist in muddy water. It is possible that such conditions were not so favorable for the deposition of coals as were the muddy waters which are known to have accompanied the burial of the material which formed the persistent and regular seams. This is a hint received from recent bores. More extended research can alone settle the question, at what line on the west, the lower workable coals of Indiana cease to exist; their horizon becoming barren, as is known to be the case near the centre of the basin in Illinois.

Near Emison's mill the lower rash coal seam is seen superimposed by a heavy bed of bituminous slate. Although small samples of impure cannel coal are obtained, this bed is of no economic importance. The workable coals are two hundred or two hundred and fifty feet below.

The Wolf hills, west of Emison's station, are an isolated mass of sandstone and shales, towering aloft like a rocky island in the level bottoms. They indicate the former existence of the Merom rock across these bottoms, and the power of the erosive currents which, sweeping down the Wabash valley, have removed their companion strata. In a well near the summit of the hill, was found at thirty feet below the surface, a deposit of lacustral clays twenty feet thick, containing much vegetable matter, and which afforded a very nauseous sample of "bilge water." From the top of the hill the veiw embraces wide alluvial plains and prairies, lake and river, with miles of woodland, stretching north to Merom, west to the prairies of Illinois, and south to Dubois hill; a similar island knoll. A bed of hard ferruginous sandstone, west of the hill, is worked by stripping, in the low bottoms on the land of Col. Finkbine. It affords good stone for rough masonry.

At Ft. Knox and the railroad bridge across Marie creek, are good exposures of the Merom rock, which is a coarse ferruginous sandstone, massive or in heavy beds and with much false bedding. Partings of iron, more unyielding than

the rock, fret the sides and overhanging arches of the precipitous wall with erratic tracery in relief. The component materials of the bed show that it was transported by a powerful current of water, along the shore of, or on the line of a sub-aqueous bench in, an ocean; the deep central part of which is located by the false bedding to the southwest in Illinois. The upper member of the rock consists of soft, laminated, slightly coherent sandstones, which on exposure, always turns to a bed of yellow sand. The more compact part at the base is from forty to seventy feet thick, and sometimes contains small irregular partings of coal or carbonaceous material of no great extent, as in Wm. Wise's well northeast, and on David Young's land, (donation 27,) three miles east of Vincennes. A bore, reported by T. H. Kerkoff, made on surveys fifty-one and fifty-two commencing at the top of the hill, gives the following section:

SECTION AT FORT KNOX HILL.

Soil and sand..............................	16 ft. 00 in.
Sandstone	45 ft. 00 in.
Crevice.......................................	6 in.
Clay shale..................................	58 ft. 00 in.
Sandstone.....................................	11 in.
	— —
	120 ft. 5 in.

W. D. Bridger gives the following section of a bore made by Mr. Beard on the north side of Marie creek and east of the Evansville and Chicago Railroad, which commences near the bottom of the above, and by connecting the two, gives a view of the strata to a depth of two hundred feet below the top of Fort Knox hill:

SECTION AT MARIE CREEK.

Coal and black slate	1 ft. 6 in.
Soapstone..	20 ft. 00 in.
Black slate..................................	9 ft. 00 in.

Gray shale	8 ft. 00 in.
Sandstone—laminated	42 ft. 00 in.
Soapstone and clay	16 ft. 00 in.
	— —
	90 ft. 6 in.

Vincennes, the county seat, is surrounded by broad alluvial plains of great fertility, except on the east, where commanding hills, surmounted by the ruined temples of the Mound Builders give variety and interest to the scenery. By Capt. Ellet's determination, low water in the river is four hundred and seventy-four feet above tide water. Geologically it is one of the highest stations in the state, as the Merom rock is found to fill a synclinal basin, of which the city is near the centre, for a space of thirty feet below the surface; consequently the rash coals outcropping at Fort Knox, Dubois hill, Bunker Hill, etc., are at least fifty feet below the streets. A bore made by Mr. Beard, several years ago, a mile east of town, is said to have discovered a seam of coal more than four feet thick. A detailed statement of this was not obtained, and the report is given for what it is worth.

A bore on Dr. Patton's land, a mile south of town, exhibits the following strata:

SECTION IN DR. PATTON'S WELL.

Surface soil	7 ft. 00 in.
Soft sandstone	40 ft. 00 in.
Coal	1 ft. 00 in.
Fire clay	3 ft. 00 in.
Hardstone (limestone?)	3 ft. 00 in.
	— —
	34 ft. 00 in.

Similar strata were passed in Mr. Fay's well near "Sugarloaf Mound," viz:

SECTION IN FAY'S WELL.

Sand	10 ft. 00 in.
Soft sandstone	65 ft. 00 in.
Gray shale	9 ft. 00 in.
Blue limestone	8 ft. 00 in.
	92 ft. 00 in.

Dr. Mantel furnished the following statement of a well bored on his land, east of the city, on upper prairie survey No. 10, viz:

SECTION IN DR. MANTEL'S WELL.

Surface soil, Vincennes plain	3 ft. 00 in.
Merom rock sandstone	45 ft. 00 in.
Coal	3 in.
Sandstone	2 ft. 6 in.
Soft soapstone	14 ft. 8 in.
Coal	2 in.
Soapstone	15 ft. 00 in.
Sandstone	10 ft. 00 in.
Soft stone	10 in.
Hard limestone	10 ft. 5 in.
Black slate	5 ft. 00 in.
Soft stone	18 ft. 00 in.
Sandstone	50 ft. 5 in.
Sandstone, soft	10 ft. 3 in.
Coal	8 in.
Fire clay	2 ft. 10 in.
	188 ft. 00 in.

Bunker Hill is of historic interest. Around this mound-like promontory, General George R. Clarke marched his little band of men, until "an army with banners" bewildered the British commandant at Fort Sackville into a surrender that signalized with victory, the only battle of the Revolu-

tion on Indiana soil. Like its namesake at Boston, here an initial blow was struck which wrested an empire from the crown of England.

The following section was taken, to which is added a statement for which I am indebted to Mr. Thomas Carr, of strata passed in shaft and bore, viz:

SECTION AT BUNKER HILL.

Outcrop—shaft and bore.

Slope	30 ft.	00 in.
Red Sandstone—Merom rock	22 ft.	00 in.
Silicious iron stones in shale	3 ft.	00 in.
Black sheety slate	5 ft.	00 in.
Gray argil. shale	2 ft.	00 in.
Dark bituminous shale	4 ft.	00 in.

Top of shaft 4 feet above high water.

Dark limestone	5 ft.	00 in.
Soft sandstone	7 ft.	00 in.
Dark shale	4 ft.	00 in.
Soft dark limestone	2 ft.	00 in.
Fire clay		6 in.
Flaggy limestone or silicious shale	11 ft.	00 in.
Silicious soapstone	6 ft.	00 in.
Dark slate	5 ft.	00 in.
Gray limestone	2 ft.	00 in.
Calcareous shale	1 ft.	6 in.
Coal—rash		11 in.
Fire clay	3 ft.	6 in.
Sand rock, compact	7 ft.	00 in.
Gray soapstone	8 ft.	00 in.
Sandstone	3 ft.	00 in.
Dark, soft limestone	1 ft.	06 in.
Sandstone	5 ft.	00 in.

(BORE.)

Soft gray limestone	8 ft.	00 in.
Dark gray shale	10 ft.	00 in.
Soapstone		6 in.
Coal parting		1 in.
Soapstone	1 ft.	6 in.
Hard limestone	2 ft.	00 in.
Sandstone	8 ft.	00 in.
	169 ft.	00 in.

These sections exhibit some variety, but are sufficiently uniform to indicate a common horizon in the upper coal measures at and below the base of the Merom rock. The place of coals M., L. and K, must be sought at a depth of from 250 to 500 feet below

On the land of Mr. Wm. Wise, one-fourth of a mile east of Pyramid Mound, is an outcrop of the Merom rock, the upper division soft like the Fort Knox sandstone, but below, becoming more compact it affords good rock of a dark reddish color. It has been worked with results satisfactory to the proprietor.

The overflowed bottom south of town, formerly "Vincennes common," has been leveed shutting off the high water of the Wabash. The city for sanitary reasons has opened a long ditch which drains the extensive lakes and ponds lying to the southeast. The discharge through the levee is by a stone culvert guarded by a skillfully arranged iron trap door, which keeps out the floods of the river, but at all other times allows free egress to the surface water. This automatic door works admirably and the project if carried to completion will result well. At a sluice where the "raised road" crosses the upper end of this ditch, the water was darkened by bushels of black crawfish, a writhing mass of hooks and claws migrating to an upper pond; a few red-clawed "hard shells" were treated as enemies by their dusky brethren, and were compelled to flee

to dry land for refuge. A swale extending from southeast of town by Deckers and thence by several outlets to the Wabash, was formerly an old bed of that river. At several stations in its course pits sunk at a dry term discovered vast deposits of white fluviatile sand.

The district in the southwest part of the county west of the E. & C. Railroad, and between the two rivers, is a low level alluvial plain that is relieved by a few ridges and knolls of small extent as Bunker hill, Dixburg hills, Rapids ridge, etc.; or solitary rocks, as LaMamelle a mound so named on account of its conical shape, and Chimney Pier, which was formerly of considerable hight and is mentioned in Maj. Bowman's manuscript journal of Clarke's expedition (one of the papers of the Vincennes Historical Society), as the "*Chimbly rock.*" These are remains of the Merom sandstone which once occupied this whole area, with a thickness of fifty to seventy feet. The bottom lands are very fertile and produce grand crops of the most profitable cereals as corn, wheat, etc., on the higher or well drained levels. They are traversed by numerous bayous and swampy basins overflowed by high water, and some permanent ponds, which are probably old river beds being underlaid with white fluviatile sand. About 20,000 acres of these swamps are covered with a fine forest of Cyrpress (*Taxodium distichum*); the large size, drooping boughs, and curious conical knees sent up from the roots of which are interesting. Other trees, shrubs and grasses, as Sweet Gum, Pecan, Persimmon, Catalpa, Cane, etc., are of southern affinity. These with several animals and reptiles of like affinity, indicate a sub-tropical climate; *and are surviving represenatives of the flora and fauna of the Lacustral period:* it is probable that here existed one of the last remnants of the Great Southern Lake.

The Dicksburg hills are a range extending two miles from northeast to southwest, composed of red Merom sandstone, capped with lacustral and fluviatile loam. Owing to the high water in White river a section connecting this sand rock with the rash coal and calcareous beds, exposed at low

water, could not be made. At an unofficial visit the latter beds were noticed as containing *Athyris*, *Bellerophon*, *Pleurotomaria*, *Macrocheilus*, *Lophophyllum*, *Myalina*, etc., the latter of great size.

East of Purcell station, on Harbin's survey, lot 8, T. 2, R. 9, a fine bed of gravel was noted, composed of the hardest stones of the glacial drift, as quartz, jasper, green stone, and occasional geodes so much worn by running water as to nearly or quite obliterate the warty excresences usually on their surface. This bed is valuable for road making, and ought to be purchased and used by the authorities. The gravel is partly conglomerated by percolation of a lime-bearing spring, which now finds an outlet at a lower level. This spring was a favorite camping ground of the savages; it was a point on the great war path from the Wabash to Kentucky, and is known as the Indian Spring.

At Earle's (Johnson's Mill,) the following section was taken, indicating the horizon of the upper rash coal:

SECTION AT EARLE'S MILL.

Red sandstone	4 ft.	00 in.
Shelly sandstone	8 ft.	00 in.
Black slate	2 ft.	6 in.
Coal, rash		3 in.
Fire clay	3 ft.	00 in.
Sandstone and covered, to creek	30 ft.	00 in.
	47 ft.	9 in.

A short distance south of this, the high ridge dividing the watershed of Wabash and White rivers terminates. Vast beds of fluviatile sands, white as if newly washed by the rushing waters, mark the ancient confluence of these rivers at a level more than one hundred feet above their present channel.

The limestone superimposing the rash coals, outcrops near Spauldingville, on the lands of L. Thorn and Mrs. C. Ray, one hundred paces north of the district school house,

N. W. qr. Sec 36, T. 2, R. 8. It is from two to three feet thick, and although argillaceous, has been burned, furnishing a strong dark-colored lime. Thin outcrops of the rash coals are seen on Thornton William's land, Sec. 1, T. 1, N. R. 9, and on Snyder's land, northeast quarter Sec. 5, T. 1, N. R. 8. They are of no great extent.

Allen and Foulk's bank, N. E. qr. Sec. 9, T. 1, N. R. 8 W., has long been worked by stripping. Entries of small extent have been driven. The coal is bright, lustrous, pure, semi-caking, burns to a white ash, and bears a good reputation for household and smiths' use. It is very similar to Alexander's coal near Petersburg. Sufficient developments have not been made to fully determine the position of this seam nor to estimate the amount of coal. The mine was not in work, and the openings had all fallen in except one. The following section was noted, viz.:

SECTION AT ALLEN & FOULK'S BANK.

(*N. E. qr. Sec.* 9, *T.* 1, *N. R.* 8.)

Slope	
Laminated sandstone..............	3 ft. 00 in.
Soapstone............................	5 ft. 00 in.
Bituminous parting...............4 in. to	0 ft. 1 in.
Soapstone, fern bed, with *Alethopteris Serlii, Sphenophyllum Schlotheimi, Pecopteris arborescens, P. (Sp ?), Neuropteris hirsuta, Cordaites borassifolia*..................2 in. to	0 ft. 5 in.
Coal N ?......................1 ft. 6 in. to	3 ft. 6 in.
Fire clay.......................	4 ft. 00 in.
	16 ft. 00 in.

A short distance east Mr. Albion McCray reports finding in his well, on N. E. qr. Sec. 10, T. 1, N. R. 8, a quantity of asphalt; a subterranean gas flow, bearing oil once had discharge here, and the volatile parts had evaporated and left the dry bitumen. Such occurrences are not uncommon;

but the stratum from which petroleum has origin is not of sufficient thickness in Indiana to justify the belief that here or elsewhere in the State paying oil wells will be found.

Hon. J. D. Williams, at Pond Creek Mills, devotes the greater part of his uplands, good "poplar land," to grazing. The sward of bluegrass covering his home pasture is a demonstrative example, showing that with persistent effort and intelligent direction this is one of the : ost lucrative branches of agriculture. Good crops of clover were seen on the adjoining farms. To the east the White river bottoms, nearly three miles wide, gleaming with midsummer corn blades, gave promise of the usual crop of eighty bushels to the acre. A tract of land was pointed out, lately sold at $20, which produced the current year a crop of corn on each acre worth twice that sum. Just below the mills in the bottom of Pond creek is a deposit of geodes, of the subcarboniferous formation, natives of Lawrence or a more distant county, they indicate a low water bar of some stream flowing at this level, the head waters of which were then cutting channels through the Keokuk limestones not less than fifty miles distant to east or northeast. More than sixty wagon loads (forty tons) have been removed for stoning roads and gateways, and the supply is still abundant. Outcrops or rather partings of coal have been seen on Autler's and McCoy's lands, S. E. qr. and S. W. qr. Sec. 20, T. 2, N. R. 8, in a coarse sandstone, well up on the side of the hill. The deposit is part of one of the upper rash coals and probably of small extent.

A bore was put down by Mr. Williams near the center of Section 35, T. 2, N. R. 8, which added to a section taken of the outcrop gives the following stratigraphic exhibit, viz.:

SECTION AT J. D. WILLIAMS' BORE.

Red clay soil—slope.........	20 ft. to 30 ft.	00 in.
Fire clay—coal ?..............	2 ft.	00 in.
Shaly sandstone...............	8 ft.	00 in.
Compact sandstone...........	3 ft.	00 in.
Shaly sandstone...............	12 ft.	00 in.

Shaly soft sandstone.........	10 ft. 00 in.
Massive quarry sandstone...	15 ft. 00 in.
Heavy bedded sandstone...	10 ft. 00 in.
(Top of bore.)	
Sandstone.......................	2 ft. 00 in.
Shale............................	5 ft. 00 in.
Blue sandstone..............	21 ft. 00 in.
Black slate.....................	4 in.
Coal M?.........................	4 ft. 00 in.
Fire clay........................	4 ft. 00 in.
Sandstone......................	5 ft. 00 in.
Gray shale and soapstone...	21 ft. 00 in.
Black slate.....................	25 ft. 00 in.
	177 ft. 4 in.

It is unfortunate that the bore was not put down deeper, as one if not two, thick workable seams are believed to exist within a short distance below. On the same section beds of massive sandstone outcrop with precipitous or overhanging walls, and afford excellent quarries. The stone is yellow, comes soft and easily dressed from the quarry, but hardens on exposure.

Nashville is situated in a depression of the ridge dividing the water shed between the two rivers. At the time of my visit a storm black with billowy clouds flecked with lightning was passing up the valley to west. The ground was full of electricity as is often the case on mountain peaks. A little girl standing in a position elevated a few feet from the surface, unconsciously became a natural electrometer. Her loose, otherwise curly hair, by the influence of the fluid was standing erect and wild, with transfigured "glory."

South of town bog iron ore of excellent quality, and apparently in masses of considerable size was observed on Phil. Cooper's land. A sufficient exposure to determine the quantity was not seen. Under the same circumstances ore occurs on the Teverbaugh and the Stucky farms in that vicinity.

Lucky Point east of the village, is a sharp promontory which extends into Montour's pond, an old river bed; marks of erosive currents may be seen high up on the hill side. Sandstone of fair quality has been quarried here for foundations. Coal M. may be found not far from 50 feet below the base of the point. North of town Mr. Bonawitz on Donation No. 59, has stripped a thin seam of coal and reports the product well suited for blacksmiths use. The opening was covered and not seen; the horizon is well up to the rash coal, and the existence of a workable seam near the surface at this level is impossible.

Wheatland on the O. & M. Railroad is surrounded by an easily won coal field, and is the commercial center of a good agricultural region. Large amounts of corn, wheat, fatted hogs and cattle, and walnut lumber are shipped from this station. To south, White river bottoms extend down the stream ten miles with a width of nearly three miles comprising some of the best corn lands in the world. Coal M. was formerly worked for local use, by stripping on Nicholson's land in a branch just west of town; it is pierced by the well at the steam mill at 37 feet below the surface—outcrops are also seen north and east of town on E. R. Steen's land W. ¼ Donation 110, and E. H. Dunn's land, S. E. ½ Additional Donation 221. At these points the seam varies from one to two and a half feet thick. A bore put down by S. L. Niblack nearly to the horizon of coal L., gives the following section, viz.:

SECTION IN NIBLACK'S BORE.

Drift	17 ft. 00 in.
Red sandstone	7 ft. 00 in.
White sandstone	6 ft. 00 in.
Dark soapstone	16 ft. 00 in.
Coal M	2 ft. 06 in.
Fire clay	3 ft. 00 in.
Dark coarse rock	20 ft. 00 in.
White sandstone	10 ft. 00 in.

Blue hard rock	8 ft. 00 in.
Dark hard rock	4 ft. 00 in.
White fine rock, argillaceous sandstone	4 ft. 00 in.
	95 ft. 00 in.

Since my visit a bore has been put down in the eastern edge of town on the land of E. R. Steen to L, having a reported thickness of over five feet.

A slope made by Clark, Nutting & Co., on the east side of the river in Daviess county, together with adjacent outcrops, develops the following section, which is given as a connected view of the rocks and coals of this vicinity:

SECTION AT CLARK, NUTTING & CO.'S SLOPE.

Yellow lacustral clay	15 ft. 00 in.
Brown sandstone	15 ft. 00 in.
Dark pyritous shale	2 ft. to 5 ft. 00 in.
Coal M	1 ft. 06 in.
Fire clay	3 ft. 00 in.
Argillaceous sandstone	5 ft. 00 in.
Soapstone and gray shale	15 ft. 06 in.
Coal L	4 ft. 7 in.
Fire clay	4 ft. 06 in.
Gray shale and sandstone	10 ft. 00 in.
Gray limestone	2 ft. 04 in.
Blue limestone with fossils	5 ft. 00 in.
Black limestone	2 ft. 00 in.
Calcareous shale	2 ft. 00 in.
Black sheety slate, with fish teeth scales etc., *Productus, Chonetes, Athyris, Spirifers* and *Crinoid* stems	12 ft. 00 in.
White soapstone	1 ft. 00 in.
Coal K, laminated coal... 1 ft. 03 in.	

Good coal......................	3 ft. 00 in.	
Best coal...........	2 ft. 07 in.	
	— —	6 ft. 10 in.
Fire clay.......................		7 ft. 00 in.
		— —
		117 ft. 3

The working superintendent, Mr. Wilson, to whom I am indebted for the above section, informed me that the company have put down nine bores on their territory, fully establishing persistant development of the coals here indicated. The upper coals, L and M, near the tops of the surrounding knolls are not worked, though it would certainly pay well. In the mine, coal K varies from five feet nine inches to six feet ten inches, with an average of over six feet; at one bore the seam measured seven feet ten inches; from actual levels K dips to the northwest twenty-eight feet within half a mile, but rises to the south two feet in one-fourth of a mile.

The Weaver bank, north of Wheatland, was formerly worked by five drifts. Coal M is here three feet four inches thick; the product, a fat, caking coal, full of gas and bitumen and of fair quality for steam and household use. It is overlaid by a soft, yellow quarry sandstone, which is found at the same horizon, and traced continuously from Sullivan county to this point. The bluff outcrop gives the following exhibit, viz.:

SECTION AT WEAVER BANK.

Slope	
Quarry sandstone—soft part...	15 ft. 00 in.
Gray shale—pyritous............	4 ft. to 2 ft. 00 in.
Coal M............................	6 in. to 3 ft. 04 in.
Fire clay..........................	3 ft. 06 in.
Soapstone, with iron stone nodules..............................	16 ft. to 25 ft. 00 in.
Slate...............................	4 in.
Coal L..............................	4 ft. 5 in.
Fire clay..........................	3 ft. 00 in.
	— —
	56 ft. 07 in.

The Weaver Coal Company having leased and purchased a large amount of contiguous land, explored their territory by putting down seven test bores; and in the extreme northern corner found the horizon of coal K at a depth of thirty-seven feet; three bores found M at a depth of from forty-seven to seventy-eight feet, while the third, and probably the fifth bore passing coal M as a mere parting of slate, found L at from sixty-seven to one hundred and eight feet.

For a full statement of these bores and a neat map, I am under obligations to E. N. Wild, treasurer of the Company. A shaft was put down which corresponds almost exactly with these bores, and gives the following strata, viz:

SECTION AT WEAVER COAL CO.'S SHAFT.

(*N. qr. Don.* 131.)

Drift	20 ft.	00 in.
Hard sandstone	41 ft.	00 in.
Fine grained sandstone	16 ft.	00 in.
Gray slate		2 in.
Black slate		4 in.
Coal M	4 ft.	6 in.
	—	—
	82 ft.	00 in.

The specimens seen from this shaft were an excellent article of pure fat caking coal. If this quality is persistent it will invite tests for gas making and coking. Coals which were not seen, are met in wells on R. Stevenson's land on Donations 135 and 136 from three to four feet thick. Fragments from the latter station, after fifteen years exposure to the air, indicate a superior stocking coal. The seam in the bed of the river at Apraw ford was not visible on account of high water. It was long worked for local demand, and quantities were hauled in wagons for blacksmiths' use. The seam is reported more than four feet thick.

At the mouth of Indian creek, coal visible in the bed of the stream at low water was not seen for similar reasons.

L is thinly developed in the banks near the bridge. On donations 242, 243 and 245, coal is reported in wells, ranging in thickness from two to three and a half feet, and is four feet thick at Simonson's bore in S. W. qr. Sec. 26. These coals are generally in isolated knolls, and to some extent have parted with gaseous as well as sulphurous matter, and consequently are, in some respects, purer if not better. Entries have been driven on Swick's and Hooper's lands, S. E. qr. and N. E. qr. of Sec. 27, T. 4, R. 8. The product is a good caking coal, remarkably pure, though liable to "slake." The following section in outcrop and bore occurs at Kelty's and Swick's, viz.

SECTION AT KELTY'S & SWICK'S BANKS.

Slope	20 ft. 00 in.
Shelly sandstone	6 ft. 00 in.
Laminated sandstone	15 ft. 00 in.
Quarry sandstone	14 ft. 00 in.
Laminated sandstone	4 ft. 00 in.
Sil. shale, with iron nodules	9 ft. 00 in.
Coal	3 ft. to 3 ft. 09 in.
Bore reported by Dr. Keith with limestone at base	30 ft. 00 in.
Coal	4 ft. 00 in.
	105 ft. 09 in.

A bore put down in the thriving village of Bicknell, found coal two feet thick at 82 feet from the surface; not being furnished a section, I am unable to determine the position of the seam.

In Mills Prairie and the old river bed leading from White river to Marie creek a muck soil is found, which to a depth of from 10 to 16 feet contains much vegetable matter, at a greater depth sand and fine gravel occurs, while beds of sand along the sides are frequent. The banks of this Prairie lake and "old river" are distinct—unmistakably marked, for wells dug *on* such banks do not expose sands

and muck, but instead clays and loes loams. It is probable that "the great denuding current" mentioned by Prof. Cox, Geological Report 1870, as sweeping from east to west across Daviess county, had its outlet for a time by this "thoroughfare" to the Wabash.

Edwardsport is situated upon a high bluff, which affords a wide view over the surrounding bottoms, and in the opinion of the citizens also complete protection from the malaria of the low lands. Coal L. outcrops in a thin seam along the top of the bluff and has long been worked in the western part of town by Curry & Co., where the following section was noted:

SECTION AT CURRY'S MINE.

Clay			12 ft.	00 in.
Shelly sandstone			18 ft.	00 in.
Argillaceous sandstone			1 ft.	6 in.
Soapstone				8 in.
Coal L:				
Fat coal	1 ft.	8 in.		
Parting				
Cubic coal		6 in.		
Parting		1 in.		
Laminated coal	2 ft.	00 in.		
Parting		1 in.		
Coal		10 in.		
	—	—	5 ft.	2 in.
Fire clay			3 ft.	00 in.
			—	—
			40 ft.	4 in.

This coal is highly esteemed by all who have used it; it presents a bright, glossy, appearance and burns to a white ash. Before the advent of railroads, this coal was coked and hauled to Vincennes in wagons, a distance of 19 miles, to supply a foundry. The coke was bright, lustrous and worked well in melting iron.

North of, and adjoining town, Shepherd & Hazlett put down five test bores on lands belong to Messrs. Simonson and Hewland. On northeast quarter Section 35, at a depth of 42 feet they found L three feet two inches thick—a short distance south at a depth of 33 feet L was found five feet eight inches; and still twenty rods south at 19 feet below the surface, L was found five feet and two inches thick. The company have since put down a shaft. The coal is fully equal to Curry's, and it is believed will fairly compete with the Washington coals of Daviess county.

The fifth bore on Simonson's land commencing at the fire clay of L, was put down to the lower seam K, and developed the following strata, viz:

SECTION IN SIMONSON'S BORE.

S. E. qr. Sec. 35, *T.* 5. *R.* 8.

Clay at level of coal L	12 ft.	00 in.
Clay and shale	12 ft.	00 in.
Silicious shale	14 ft.	00 in.
Limestone	1 ft.	2 in.
Calcareous shale	4 ft.	4 in.
Black slate	3 ft.	6 in.
Coal K	6 ft.	00 in.
Fire clay	1 ft.	00 in.
	54 ft.	00 in.

The borings from this test were reported free from sulphur.

South of town Shepherd, and Hazlett work coal K by a slope on the land of Dr. B. F. Keith where the following strata are seen, viz:

SECTION AT DR. KEITH'S MINE.

N. E. qr. N. W. qr Sec. 12, *T.* 4, *R.* 8.

Soil and loess	12 ft.	00 in.
Argillaceous sandstone	8 ft.	00 in.

Soapstone			08 in.
Coal L			2 ft. 6 in.
Fire clay			3 ft. 00 in.
Sandstone, laminated			3 ft. 00 in.
Sandstone, laminated			14 ft. 00 in.
Bituminous limestone			3 ft. 00 in.
Black sheety slate		6 in. to	1 ft. 6 in.
Coal K:			
Laminated coal	1 ft. 6 in.		
Parting, pyrite and smut	00 ft. 00½ in.		
Compact coal, part block	1 ft. 4 in.		
Smut parting	0½ in.		
Blacksmith—fat coal	1 ft. 6 in.		
	— —		4 ft. 5 in.
Fire clay (in bore)			4 ft. 00 in.
White sandstone and shale			30 ft. 00 in.
Soapstone becoming darker			27 ft. 4 in.
			— —
			113 ft. 5 in.

The Company elevate their coal by steam engine and have a capacity for 40 miners and 100 tons of coal per day. The partings in this coal contain considerable pyrite, which being banded, may and should be separated in mining, to supply chemical works. This coal may be washed and coked with profit. The black slate roof of the seam contains massive boulders of pyrite weighing from one hundred to one thousand pounds surrounded by a black "clod" filled wlth *Productus*, *Chonetes* and *Athyris*.

On southeast quarter of Section 12 belonging to Dr. Keith, coal L shows a thickness of thirty inches on the side of the bluff, and at low water he has drifted in fifty feet on K, where the seam is full five feet thick with the bottom and middle divisions remarkably pure and free from sulphur.

A section very similar to the one given in Dr. Keith's

slope was taken on the bluff in front of town. A repetition is here unnecessary.

The following fossils occur in the limestone and calcareous shale, overlying coal K along the river landing, viz: *Productus costatus, P. punctatus, P. semireticulatus, P. longispinus, Spirifer cameratus, S. lineatus, S. Kentuckensis, Allorisma (sp.?)*, Crinoid stems and spines, *Hemipronites crassus, H. crenistria, Chonetes mesoloba, C. spinuilifera, C. (sp.?), Bellerophon carbonarius, Rhynchonella Osagensis, Orthoceras Rushensis, Lophophyllum proliferum*, and an undescribed coral. Half a mile south of town the loess loam exposed in a railroad cut contained characteristic shells, a list which is given in geology of Sullivan county—Indiana Report 1870. This bank offers good specimens of the tubes found traversing *exposed faces* of this deposite, and which furnishes ground for illustration and chemical analysis in the report on Geology of Missouri 1855. Here an opportunity was afforded of seeing these tubes excavated by a sand wasp, which, after completing the burrow, cementing the sides and a projecting crown to ward off the rain, utilized the home so constructed for the deposit of her eggs and a supply of food for the coming race of young. The same facts were noted by one of the editors of the American Naturalist at Merom, Indiana.

A short distance northwest of town coal M. outcrops or is found in wells, having an average thickness of over three feet; so that the combined thickness of the coals in the vicinity of Edwardsport, including K and L amounts to nearly twelve feet.

Sandborn is surrounded by broad alluvial lowlands traversed by many wide praire like swales, with occasional knolls and ridges covered with Lacustral and fluviatile sands. In the "old river" swale, which has an elevation of thirty feet above low water in White river, two bores, one east, the other west of town, were put down to a depth of eighty feet, or fifty below the present rock bottom of the river, in which mucky quicksands containing much vegetable matter were found extending to that depth and

which may extend to a still greater depth. Similar deposits are also found in digging wells at least fifty feet higher than the surface of the swale.

Putting these two facts together, we may safely conclude:

1st. That this valley was eroded to a depth of fifty or more feet below the bottom of the present water courses by the sheet of water, which resulted from the glacial iceflow that was stranded a short distance to the north.

2nd. That afterwards this deep chasm, cut down through solid rock, was silted up with muck, light unworn sands and vegetable matter, (*Erie clay*) to a thickness of more than one hundred feet during the period when a great lake occupied southern Indiana, etc..

3rd. Since that time, the rivers have been removing these materials until they have reached their present channels.

Coal K. was formerly worked east of town. The roof slate, containing fish teeth, scales and spines (*Pretrodus occidentalis*), is well developed, and when broken up in great slabs, exposes a coal which, from a few fragments picked up, is bright, solid, semi-caking and well suited for stocking. It is reported as well liked by blacksmiths, and over two feet thick. The seam was covered with water. On the adjoining hill, northeast quarter, southwest quarter, Section 2, T. 5, R. 7, a bore was made for C. E. Crane by E. L. Ferguson with following results, viz:

SECTION IN CRANE'S BORE.

Soil and sand	14 ft.	00 in.
Yellow clay	7 ft.	00 in.
Soft sandstone	10 ft.	00 in.
Compact sandstone	5 ft.	00 in.
Soapstone (cal. slate?)	4 ft.	06 in.
Black sheety slate	6 ft.	04 in.
Coal K—part block	3 ft.	00 in.
Fire clay	3 ft.	00 in.
	52 ft.	1 in.

Russel, Crane & Co., then bored near the railroad track, northeast quarter, northwest quarter, Section three T. 5, R. 7, and found the following:

SECTION IN RUSSEL, CRANE & CO'S BORE.

Soil, sand and muck..	42 ft. 00 in.
Sandstone	12 ft. 00 in.
Rash coal	3 ft. 02 in.
Soapstone parting	5 ft. 00 in.
Coal K?	1 ft. 6 in.
Hard sandstone	6 ft. 00 in.
Clay and iron balls	16 ft. 00 in.
Black slate	9 ft. 04 in.
Slaty cannel	3 ft. 00 in.
Coal I?—part block	3 ft. 00 in.
Fire clay	1 ft. 00 in.
	102 ft. 00 in.

Encouraged by this bore Messrs. Crane & Co., were excavating a shaft, which at the time of my visit had been sunk to a depth of forty-two feet through dark clays and quick sands, and was being prosecuted with energy. Levels carefully made by an engineer between the different bores at Sandborn, show that K has a local dip to southwest of twenty-four feet per mile. A bore made by Hill Bros. north of town on northeast quarter, southeast quarter, Section 34, T. 6, R. 7, shows the following section from their record:

SECTION IN HILL'S BORE.

Clay and sand	16 ft. 00 in.
Sandstone	10 ft. 00 in.
Soapstone	5 ft. 00 in.
Slate	10 ft. 00 in.
Coal L	8 in.
Fire clay	1 ft. 06 in.
White sandstone	26 ft. 04 in.

Soapstone	7 ft. 00 in.
Sandy shale	3 ft. 06 in.
Black slate	03 in.
Coal K	06 in.
Clay parting	09 in.
Coal K	2 ft. 08 in.
Fire Clay	3 ft. 04 in.
Potters' clay	5 ft. 06 in.
Sandstone	5 ft. 00 in.
Hard limestone	3 ft. 05 in.
Limestone	21 ft. 06 in.
Coal I	10 in.
Fire clay	3 ft. 00 in.
Potters' clay	6 ft. 00 in.
Argillaceous sandstone	6 ft. 07 in.
Blue limestone	2 ft. 01 in.
Soapstone	04 in.
Blue limestone	05 in.
Sandstone	13 ft. 00 in.
Bituminous soapstone	25 ft. 00 in.
	180 ft. 02

Seven other bores made in this vicinity, discovered from one to three seams of coal in each, but as the results do not vary very materially from the sections here given, they will not be repeated. We may conclude that the existence of workable areas in this vicinity are possible, but searchers will often meet with disappointment.

Freelandsville is located well upon the summit of the divide which separates the White and Wabash rivers; and at an elevation of one hundred and fifty-two feet above the latter. The town and vicinage is noted for comfortable homes, surrounded by gardens stocked with vegetables shrubs and flowers, and well kept farms, combining the pleasures and thrift characteristic of Holland, from whence a majority of the citizens hail. Immunity from malarial diseases is claimed with truth; and it is suggested that the use of filtered rain water would, in some degree, procure

exemption from the inflammatory diseases which sometimes prevail here, as elsewhere on loess soils. Wells dug in the northern part of town, pierce the Merom sandstone, as will be seen by the following section, viz.:

DR. FREELAND'S WELL.

Soil	12 ft. 00 in.
Soft, white and red sandstones	51 ft. 00 in.
Silicious shale	1 ft. 00 in.
	64 ft. 00 in.

North and south of town, along the sides of the divide, detached blocks of limestone are noted, indicating the horizon of the thin rash coal seams.

At Cox's hill, Sec. 8, T. 4, R. 8, this stone is well developed, and has been burned profitably for lime.

SECTION AT COX'S HILL.

Clay soil	5 ft. 00 in.
Laminated Merom sandstone.	5 ft. 00 in.
Thick bedded Merom sandstone	10 ft. 00 in.
Soft, friable, white sandstone	15 ft. 00 in.
Argil. limestone—conglomeratic	3 ft. 00 in.
Clay parting 1 in. to	04 in.
Dark limestone, containing crinoid stems, corals, *Athyris subtilita*, *Productus punctatus*, *P. semireticulatus*, *P. longispinus*, *Chonetes mesoloba*, *Spirifer lineatus*, *Orthis carbonaria* and *Rhynchonella Osagensis*	4 ft. 00 in.
Place of rash coal	
Fire clay—potters' clay	1 ft. 06 in.
	43 ft. 10 in.

A similar section was noted on the Hern farm; donation one hundred and fifty-two, near High Point; with the

addition of a carbonaceous clod at the "place of the rash coal." The stone at this station is four to six feet thick, and when burned, produces strong dark colored lime.

It may here be mentioned that this *double limestone* has been seen in almost continuous outcrop, marking the horizon of the upper rash coals, in a belt one hundred and fifty miles long; commencing at Snake Knob in Warrick county, thence continuing north along the western boundary of Pike, and through near the center of Knox, thence northwest through Sullivan county crossing the Wabash river near the Narrows above Graysville, and again nearly north by Marshall, Paris, and Garrett's Mills to Fairmont, in Vermillion county, Illinois; which shows that the limestones are more persistant than the rash coal seams, which are often absent, or very slightly developed. At several of the localities mentioned, this stone is from ten to thirty feet* in thickness, and is rich in fossils.

At Bruceville, the horizon of the rash coals is seen in the valleys near town, but ascending against the dip to the east. In the hills and at the railroad cut four miles east, the Merom sandstone develops a thickness of ten to eighty feet. Mr. Willis' well at the hotel in town, pierces this deposit to a depth of fifty feet; the stone appears compact, but on exposure to air, is soon resolved to sand. Denuding forces of great intensity have exerted their power in excavating valleys and depressions in this vicinity, some of which had their origin before the loess or lacustral period, while others plainly indicate fluviatile origin. Messrs. Witherspoon & Emison put down a bore in the valley south of town, and for the following report I am indebted to Dr. Witherspoon:

BRUCEVILLE BORE.

Soil, and fluviatile drift.................	20 ft. 00 in.
Soft, red, Merom rock..................	20 ft. 00 in.

*Marshall and Paris, Illinois.

Silicious shale	2 ft. 00 in.
Hard ferruginous, argillaceous, conglomeratic limestone	2 ft. 00 in.
Black slate—upper rash coal	02 in.
Fire clay	1 ft. 00 in.
Soapstone and silicious shale	20 ft. 00 in.
Coarse sandstone	8 ft. 00 in.
Bituminous soapstone	4 ft. 00 in.
Hard rock (limestone) in layers, with partings of clay	42 ft. 10 in.
	120 ft. 00 in.

East of town the surface coals are covered with two to three feet of bituminous slate, some of which approaches in a small degree to Cannel coal, and will burn. Coal N? has been worked on the Denny land, lot one hundred and forty-three, and Willis,' lot one hundred and twenty-three. The seam was covered with water, but was reported from two to three feet thick.

At Mr. S. Hoffman's, lot one hundred and eighty-three, a mile southwest of Bruceville, occurs a heavy bed of slaty cannel. An entry was driven by Mr. Hoffman, twenty-five feet under the hill, which had fallen in at the time of my visit. He reports a considerable thickness of cannel, and specimens presented by him were fair to good samples of that kind of coal. The horizon, however, does not justify the hope that a workable bed may be found at this level.

The following section was taken, viz.:

SECTION AT HOFFMAN'S BANK.

Slope	30 ft. 00 in.
Red and white Merom rock	18 ft. 00 in.
Silicious shale and iron nodules	3 ft. 00 in.
Flaggy sandstone	4 ft. 00 in.
Silicious shale and shaly sandstone	25 ft. 00 in.
Conglomeratic sandstone	2 ft. 04 in.
Pyritous soapstone	08 in.

Lower rash Coal:

Slaty coal.................	08 in.	
Cannel slate.............	2 ft. 02 in.	
Coal, caking	2 in.	
	— —	3 ft. 00 in.
Fire clay..................		3 ft. 00 in.
		— —
		89 ft. 00 in.

A bore put down by Messrs. Sheperd & Hazlett on the adjoining hill to the south, discovered, as I am informed by Mr. Sheperd, great irregularities in the level as well as the thickness of this coal. A search for coal at this point, should be directed towards the lower seams M and L, which probably underrun the surrounding region.

ECONOMIC GEOLOGY.

Alluvial bottoms are so prevalent in Knox county, that they give character to its agriculture. The fertility of these soils is proverbial. Corn is King. Good crops of sorghum, potatoes and wheat are also produced. The upland soils are generally thinner, yet with careful cultivation, return a fair yield of wheat, oats and hay. Considerable areas, characterized by an original growth of sugar trees, poplar, walnut, ash, etc., are well suited to the growth of Indiana bluegrass. Being situated rather to the south of the grazing zone, exemption from the effect of hot suns and drought may be procured by underdraining and the growth of alfalfa. The vigorous roots of the latter, pierce the ground to a depth of from four to ten feet, which renders this great hay and grazing plant independent of sun or drought. It is especially adapted for the sandy barrens, and ash gray clays, and grows luxuriantly on alluvial soils.

FRUIT.

Fruit growing is an important interest. Favored by a genial climate which protects from the biting blasts of winter, the tender fruits such as peaches, pears, grapes and berries, mature with superior flavor and brilliant color. Lake-like ponds, and the surrounding rivers and swamps, farther regulate and modify sudden atmospheric changes. Almost perfect immunity from untimely frosts and "severe snaps" is enjoyed on the promontory-like ridge which passes north-south through the central parts, especially along the belt of fluviatile sands which cap the high bluffs of the Wabash. In autumn the air on the highlands is burdened with the fragrance of the ripening fruitage.

Pear and apple trees are endowed with great longevity, and grow to wonderful size. The orchard planted by Col. Vigo, who was an effectual aid to the patriot cause in the Revolutionary war, still survives in good bearing. Apple trees, two to nearly four feet in diameter, were seen and measured. A pear tree, on the Ockiltree farm now owned by Wm. Wise, Esqr., has become historical. Rev. H. W. Beecher visited the tree many years ago, then in the full vigor of its fruitfulness, and published an interesting and graphic account of this "*giant of its race.*" The "Great Pear Tree" was twelve feet in circumference near its base, one hundred and twenty feet high, with a lateral spread of sixty feet from the trunk, and bore an average crop of fifty bushels. Riven by lightning, it survives only in history and tradition, after a life of nearly three score years and ten.

Mr. S. Burnett, one mile east of, and at an elevation of only 60 feet above Vincennes Plain, has devoted 183 acres to the production of fruit, 40 acres of which contain 1,100 choice grafted apple trees in bearing; Winesap, Rawls' Janet, Yellow Bellflower, Fall Pippin, Carolina Red June, and Early Harvest, are standard varieties, and generally bear a full crop of well colored, fragrant and palatable fruit, which commands a good market—the earliest varieties any price asked. He has six hundred budded peach trees and will plant the coming spring of 1874, at least 500 more to repair the damage of the excessive winter of 1872–3; he relies on having three good crops successively—has had an entire failure but three times in the last twenty-one years, viz: 1856, 1864 and 1873. The extreme winter of 1872 damaged this orchard greatly, except on the highest ground.* His peaches are reported as highly colored,

*Careful observation has determined that practically, nature accords with the theories of science. Cold air is heavier than warm air, and will consequently settle to the low lands, hence we find that hills surrounded by deep valleys will afford protection in proportion to their hight, against sudden "cold snaps." I have often observed that a knoll fifteen to twenty feet high in an orchard, will draw

sweet and fragrant. "Hale's Early" proves hardy, a reliable bearer, ripens from 4th to 20th of July, and is highly remunerative. Mr. Burnett has a vinyard of six acres; the Catawba proves a failure, but the Concord and Ives Seedling are hardy, good bearers and pay at the rate of $300 per acre. His grapes command a ready market at Indianapolis, Toledo, Cleveland and Buffalo. Strawberries, raspberries and blackberries grow kindly under his management, and maturing early command highly remunerative prices. Gooseberries are produced at the rate of forty to fifty bushels per acre, and sell at $2 per bushel.

Mr. F. M. Fay's farm of four hundred and forty acres adjoins the city on the east. The bluffs here attain an elevation of one hundred feet above Vincennes Plain. Still twenty-seven feet higher towers "Sugar Loaf Mound,"

Mr. Fay, taking advantage of his favorable soil and situation, has devoted two hundred acres to fruit production; he has five thousand five hundred choice grafted apple trees, one thousand five hundred budded peach trees and two thousand five hundred Concord and Ives Seedling vines. The above mentioned vines succeed well, but he has found the Catawba an utter failure. His fruit creates a demand beyond his ability to supply, and competes triumphantly with that grown in southern Illinois, being more vividly colored, sweeter, and free from stings of curculio or other insects. This experience establishes a proud preeminence to the fruit growers of Knox county. The numerous railroads intersecting at Vincennes give competing rates north, south, east and west. The current prices in 1870 for peaches was $2 40 per bushel, for apples $1 90 per barrel, and Mr. Fay's farm that year gave an income from peaches sold of $10,000, from apples of $2,000.

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the narrow line between the life or death of peach trees; which perish at—18° Fah. As a general rule, subject to local variations, it has been found that, an elevation of fifty feet in case of sudden atmospheric change, will mitigate the cold 3°, one hundred feet 5°, and one hundred and fifty feet about 8°.

M. D. Bowman has a farm of two hundred acres, Donation one hundred and six, five miles southeast of Vincennes. The soil is a bright mulatto loam, almost as rich as river bottom. It was originally covered with Poplar, Walnut and Sugartree timber, and maintains a sward of blue grass almost equal to the upper Wabash grass lands. He has 37 acres in small fruits and melons, as follows, viz:

Strawberries	10	acres.
Raspberries	6	acres.
Blackberries	7	acres.
Currants	4	acres.
Grapes	2½	acres.
Cherries	2½	acres.
Nutmeg Melons	5	acres.
	37	acres.

Strawberries and raspberries make the most satisfactory returns; it costs $50 per acre to bring a plantation in bearing which yields $100 per acre per annum. A strawberry plantation (Wilson's) will live four to eight years, and while making good returns, will loosen and fertilize the soil equal to a set of clover. A raspberry plantation is good for about twenty years; he plants Red and Black Cap; all other varieties not succeeding. His plantation shows thought, persistent care, and thrift, and is a model "berry farm."

A short distance north, the highly ornamented grounds of J. H. Simpson & Bros. Donation No. 4, are an attractive feature in the landscape. Their nursery, heavily stocked with the *hardy* varieties of apples, peaches, pears, vines, and a large quantity of evergreens and ornamental shrubbery, covers *one hundred acres.* Their twenty-five acre orchard contains fifteen hundred apple, and five hundred pear trees. The sales made by the brothers amounted to $ 20,000 in the year 1873: the present year their facilities will enable them to increase their business to $40,000. The above mentioned fruit farms are merely representative. Many others

noted as Alexander & Roseman, J. G. Miller, John Alexander, E. Smith, J. Ewing etc., have orchards comprising many thousand bearing trees.

The choice quality of these fruits, the certainty of the crop and the facilities for cheap transportation, justifies the belief that at Vincennes fruit could be profitably canned or preserved on a large scale.

VINEYARDS.

Much attention has been given and a large area devoted to vineyards. Persons with long experience in Europe declare that this is the Rhine land of America, and insist that their products compare favorably with the wines of fatherland. The Concord and Ives Seedling are standard varieties, hardy and prolific. The Hartford and Delaware are largely grown; but Norton's Virginia makes the best wine, fairly rivaling good European brands in brilliancy, bouquet and body.

M. DeBuysseret's vineyard comprises about ten acres. He makes wine a specialty and produces in superior quality from twelve hundred to fifteen hundred gallons annually. Wm. Schappacher and M. D. Wendling have each, about four acres in bearing from which they make wine. M. T. Bailey's vineyard in area equals the last mentioned and he has thirty barrels of red wine ripening in his cellars.

George Omode makes red wine from his vineyard of ten acres on the Bishop's land. He considers Norton's Virginia as superior. Messrs. Underwood and Hill, three miles northeast of Decker's, have ten acres planted. They market their grapes with profit. These vineyards and many others of equal or greater extent are noted as demonstrative experiments, showing that here a mild climate and fertile soils offer a combination of favorable circumstances worthy the attention of the unfortunate millions being driven from the old Rhineland by results of war.

TIMBER.

This county is noted for the great size of the original forest trees, consisting of Poplar, Walnut, Burr, Post, White and Overcup oaks, Elm, Ash, Gum, Cottonwood, Sycamore, Mulberry, Hackberry, Catalpa and Pecan. Poplar, Walnut and Cottonwood trees with trunks sixty feet long and from five to eight feet in diameter were not uncommon, and Sycamores ten and even twenty feet in diameter are reported. James E. Baker, county Surveyor, measured a Sassafras four feet in diameter on Section 1 T.1 south of R. 12: a Sycamore eleven, and a Mulberry over two feet in diameter, on the southwest quarter Section 1, T. 2, R. 8. He notes a Pecan tree near Sandborn eight feet in diameter, while many Cypress trees two, four and five feet, and Catalpas two to three feet were seen. One of the latter twenty-five inches in diameter had thirty-seven annual rings of growth, indicating an increase of size during a third of a century of more than .67 of an inch per annum. A mulbury stump tested in the same way, indicated a growth of .45 of an inch per annum. These facts show that waste lands may be planted to these valuable trees with an annual profit of from five to eight dollars per acre. The fine original forests are mostly destroyed, and a tangled undergrowth is thrust up by the fertile soil to take its place. Sufficient timber for local purposes still exists with a large surplus of the common kinds to spare.

DURABILITY OF TIMBER.

A Catalpa gate post set in the ground by Col. Decker in 1780 near the school house on Deshee creek was cut up for firewood in 1871 and found in fair condition after doing service for nearly a century. President Harrison on his visit to Vincennes in 1840, publicly called attention to the fact that a picket fence built by him along the river in front of his former residence, was in good order after forty years service. This fence was cut away for firewood, but on

examination the portion of the posts (Mulberry and Catalpa) buried in the earth was found sound as if cut yesterday. Catalpa posts set by General Harrison about the Governor's house in 1808 were taken up, Mr. Pidgeon informs me, a few years ago and being sound, were reset in another place. At the Parke homestead now the residence of Mr. John Wise, a picket fence made by Judge Parke in 1809 still constitutes a sufficient protection against stock on the river front.* It is of Mulberry wood, generally set with tops down; those planted in that way are in the best preservation. The Sapwood of course is gone, but the balance is sound as "heart of hickory" after sixty-four years service. The endurance of this timber is certainly wonderful. I have seen no similar experience recorded. The examples mentioned can be seen at this day, and if allowed to remain undisturbed, will survive to tell the same tale of endurance after this generation of man has passed away.

DRAWBACKS.

The sandy oak barrens, covered with scrubby black jack oaks, are unsightly, yet this thin soil produces a comfortable supply of watermelons and sweet potatoes. The large ponds and swamps are a serious evil. For sanitary as well as economic reasons, they may, can, should and *must* be drained. When private enterprise is not sufficent the public should offer a helping hand.

Monteur's pond can be drained by Pond creek, or better, by direct route to White river; and the river bottom ponds and swamps may be tiled with a "trap outlet" which would reject the flood waters of the rivers; or when the bottoms are leveed as they should be, windmill pumps can be used

*A row of Sycamore and Cottonwood trees planted at the same time and place averaged three feet in diameter: three of the largest were measured, as follows:

No. 1 Cottonwood	11 ft.	2 in. girth.
No. 2 Cottonwood	11 ft.	7 in. girth.
No. 3 Cottonwood	13 ft.	7 in. girth.

Making an average of over four feet in diameter.

with advantage. The uplands are considered healthy; but malarial diseases are not unusual on the low lands and bottoms; this may be avoided by contriving to have the living and sleeping rooms, occupied after night, not less than ten or fifteen feet above the surface, as malarial gases are heavier than common air, and rarely accumulate to a greater depth than ten feet even in the lowest lands.

ROAD MATERIALS.

Well developed beds of terrace gravel are found south of Emison's, in the vicinity of Vincennes, in the bottoms to the southwest, and at Indian Springs. This is the best known material for road making, and should be freely utilized. Good roads are a necessity in progressive civilization.

COAL.

From the foregoing examinations it will be seen that the great, reliable seams K, L and M are well developed along the whole eastern side of the county, or in the adjoining counties of Pike and Daviess within half a mile of the Knox line. We may say grandly developed with thick seams varying from fair to extra caking and semi-caking coals. Enough has already been opened or tested by bores at Edwardsport, Bicknell, Indian creek, Wheatland, Pond creek and Brush creek, to supply the hearths of an empire; surely enough to warrant the opinion that with only twelve to fifteen miles of transportation Vincennes can promise manufacturers the necessary fuel to drive their engines as cheap if not cheaper than any western city. These seams pass beneath the surface going west with a dip, variable but heavy. The upper rash coals (not workable in this State) are alone seen in the western half of the county; but reasoning from experience in similar localities, we may expect to find these lower seams, K, L and M, with a combined thickness averaging over ten feet, underlieing more than one-half of the whole county.

Barren areas will be met here as elsewhere in the coal

measures. The occurence of heavy and massive beds of limestone in the deep bores, made within the last six months along the Wabash river, presents new and anomalous features. Noting the fact that the horizon of the lower seams is barren in Central Illinois to the west, it is possible that even along the Wabash thin or barren areas may prevail, the conditions suitable for the deposit of heavy limestone not being favorable for the production of thick seams of coal. Enough, however, is seen, to say that Knox county is rich in coal.

IRON AND OTHER MINERALS.

The nodular ores of iron found in connection with the coal seams are not in sufficient quantity to be valuable. The bog ore south of Nashville is of good quality, and examinations should be made to ascertain the quantity. The pyrite which falls from the roof shales ot coal K is of value and should be manufactured into sulphuric acid, or used at home for deodorizing cesspools, etc. Minute nuggets of copper, lead and gold, imported by the boulder flood, are rarely found. Interesting as relics, they are of no economic value.

STONE FOR BUILDINGS.

Beds of red sandstone, suitable for foundations and rough masonry, occur west of Wolf hills, in the "bottoms," and on Wise's land east of Pyramid Mound. The Merom sandstone is generally too soft for building purposes, and is more valuable, after sufficient exposure to wash out the iron, for glass making. Good brown sandstone, adapted for hammered masonry, and in unlimited quantities, is found on Williams' land Sec. 35, T. 2, R. 8, and Sec. 2, T. 1., R. 8. The limestones which accompany the horizon of the rash coals is generally argillaceous or pyritous; in the first case, on exposure, chipping or breaking into cubes; in the other, disintegrating. Local exceptions to this rule are seen, and in such cases the stone may be burned, producing good

strong dark colored lime, which requires months to set, but forms a compact cement.

CLAY.

Clay for bricks is found in abundance and of excellent quality. The under clays of the coals are plentiful, worth nearly as much as the coals, and are suitable for the manufacture of fire brick, tiles, terra-cotta and potters' wares.

MANUFACTURES.

At Vincennes are several first-class grist mills, foundries and machine shops, railway repair shops, planing mills, breweries, etc. Negotiations are pending for the erection of a blast furnace and extensive rolling mills. These last establishments, giving new life to business, will require such an amount of fuel as to justify the city in refusing any additional subsidies to railroads, unless they will contract to transport coal at a cent a ton per mile.

CORN SYRUPS.

The Vincennes Starch and Sugar Manufactory, Keyt, Thompson & Co, proprieters, in the northern suburb of Vincennes, deserves mention on account of the novelty of the enterprise and as a tribute to the inventive genius of an Indianian. Five hundred bushels of corn are used each day. The grain is first soaked in water about one week; by this time all suitable elements have been changed, according to accurate analysis, into thirty-six pounds of starch per bushel, but by the process here carried on, twenty-three to twenty-four pounds are realized. The grain is then ground, and by an addition of sulphuric or tartaric acid, or barley malt, the starch is converted into syrup (glucose). The acid performs this work without waste, and is then neutralized by use of lime until the product no longer tinges litmus paper. The product is boiled slowly four to six hours, until the lime and extraneous matter is precipitated. The syrup, by this time, reduced to 20° Baume,

is filtered and the process is completed by boiling to the standard of 40° Baume. The syrup is now ready for market, is similar in flavor to maple molasses, and meets with a quick sale. The yield is two and half gallons per bushel, or thirty barrels per day. The manufacture is highly remunerative. The offal, containing fifty per cent. of the fattening element of the grains, is fed to cattle and hogs with profit. Mr. Wm. H. Keyt, of Vincennes is inventor and patentee of the process.

TRANSPORTATION.

The Wabash and White rivers are navigable for steamboats a small part of the year. The Evansville and Chicago Railway traverses the county from north to south; the Ohio and Mississippi Railway from east to west, and the Indianapolis, Vincennes and Cairo Railway passes from northeast to southwest. A company is organized and intends building a road from Vincennes by Petersburg to the Ohio river, and I am informed that a short line is proposed from Edwardsport to Petersburg. These roads, actual and prospective, will afford ample facilities for commercial intercourse.

FAUNA.

The early French missionaries, in their journals, mention the abundance of wild animals in this county, especially those now extinct, as buffalo, elk, deer, beaver, porcupine and bears, also paroquets* and turkeys, all in great numbers. Many small circular depressions, often filled with water, are recognized as buffalo wallows.

*Paroquets migrated West about 1845-6.

ARCHÆOLOGY, ETC.

Although just siezing the confident pulse-beat and promise of to-day's young manhood, Vincennes is venerable with antiquity. Her history reaches back to the infancy of American civilization. French explorers, in 1688, found here the populous Piankashaw-Miami town, Chip-kaw-kay. In 1702 a band of Missionaries, S. J., returned to plant a post which has long exerted a controling influence over the great valley, and remains a monument to their heroic deeds. Rejoiced to find new worlds for ransom, they came without guides or interpreters, without arms or armor, bearing only the story of the cross, peace and good will to men. Rival creeds have delighted to honor and appreciate the sublime devotion which clusters so many holy memories about the "Old Post," and the Missionary brotherhood.

In 1763 this region was ceded with the Canadas to England. In 1779 the British establishment at Vincennes (Fort Sackville), was besieged and captured dy the Patriot forces under General Geo. R. Clark. This event transferred the whole territory northwest of the Ohio to the American Union. In 1800 the territory of Indiana was organized, and Governor Harrison established the seat of government here*. At each transfer tq France, to England, to the

*Vincennes was still an outpost, surrounded by merciless savages and depending alone on military trains for communication with the world. The lumber for the Government House had to be sawed by hand and the nails and hinges were made at a smith's forge. The Governor knowing the possibilities of war and the horrible death awarded prisoners by the Indians, placed the powder magazine of this command immediately beneath the family room in his residence. The town might be overpowered, but the Indians would never practice their fiery tortures on himself and family.

United States, Vincennes brought the domain of an empire to endow her new sovereign.

When first approached by Europeans, the Miami Confederacy claimed and possessed the region watered by the Wabash and its affluents, and the contiguous territory now constituting the State of Indiana, parts of Illinois, Ohio and Michigan. Chip-kaw-kay was one of their most populous and perhaps their most permanent town; not a trace of which remains at this day, except a few heaps of ashes exposed the current year (1873) in preparing a roadway. Erratic and averse to labor, their polity did not affect permanent homes or fixed habitations. Their towns and villages were merely favorite camping-grounds.

But extensive *Shell heaps* are found at many stations along the Wabash and its tributaries containing fluviatile and land shells and the bones of a few animals, which signify the *permanent* residence of a people relying on agriculture and aquatic life for sustenance; hence we infer, that the people whose existance is indicated by these shell heaps were not related to our savages. Again, stone cists and vaults containing the bones of many persons of all ages and sexes irregularly mingled with remains of funeral fish food, are often found, sometimes as intrusive sepulchers on sides or tops of the mounds; we conclude that these are the remains of the conquerors of the most ancient people who were afterwards themselves dispossessed by the Indians—*An intermediate litoral "Race of Fishermen,"* who to some extent adopted the habits, usages and even religion of the conquered.

The extensive shell heap at Edwardsport, one hundred and fifty feet long sixty feet wide and over two feet deep, containing shells of *Unio Paludina* and *Helix*, the bones of fishes birds animals and man, with chips and fragments of flints and pieces of pottery, are referred to this age; also similar heaps at the west end of the wagon bridge, another at the side of the levee near the railroad bridge, both on the west bank of the Wabash opposite Vincennes. Tradition

tells no story of this people, but we have a near type in the Nazches and Choctaws of the south.

THE MOUND BUILDERS.

More ancient than these shell heaps, dating back beyond the thousand years noted by the annual growth of our forests, are numerous monumental remains of which the past is silent. "Not entirely voiceless," they tell of a people who once possessed the valley of the continent. Peaceful and law-abiding, they were skilled in agriculture and the arts of the "Stone age," and executed works that required the united and persistent effort of thousands, under the direction of a well matured design. In the comparative absence of warlike implements, we conclude that this work was a labor of love, and not of fear; that it was inaugurated and directed by a Regal Priesthood, to erect votive temples in honor of the Sun, a visible Creator of comfort, food and life.

The works seen in Knox county consist of mounds of habitation, sepulchral and temple mounds, and number over two hundred with probably as many more not yet visited.

Mounds of habitation are found in the north and southwest parts of Vincennes, along the summit of the high river bluff south of Edwardsport, on the wagon road between the latter town and Sandborn and on the top and sides of the Dixburg hills. A group of fifty-two mounds on the Vaulting farm six miles southeast from Purcell showed more attention to regularity than is elsewhere seen, being arranged somewhat in regular lines from north to south and from east to west.

Sepulchral mounds are rare. The only one certainly identified was situated centrally in the last mentioned group. Explored by Mr. Samuel Jordan, it was found to contain human skeletons and round-bottomed pottery. Plumb-bobs, stone shuttles, spinerets and numerous fragments of pottery have been found on S. Catt's land (Sur-

vey 22) adjoining. Other *tumuli* of this character will reward the future explorer.

Temple Mounds.—This region was well to the center of the Mound Building Nation. Remote from the dangers incident to a more exposed situation and encircled by a bulwark of loving hearts—forts, walled enclosures, and citadels were unnecessary, and not erected as at exposed points on their frontier. Perhaps the seat of a Royal Priesthood, their efforts essayed to build a series of temples which constituted at once capitol and holy city—The *Heliopolis of the West.* Three sacred mounds thrown upon or against the sides of the second terrace or bluff east and southeast of Vincennes are the result, and in size, symmetry and grandeur of aspect, rival if not excel any prehistoric remains in the United States. All three are truncated cones or pyramidal; and without doubt, erected designedly for sacred purposes, the flat area on the summit was reserved for an Oratory and Altar as in the *Teocalli* of Mexico.

The *Pyramid Mound* (on the Miller farm common lot 83, Div. B.), one mile south of Vincennes, is placed on a slightly elevated terrace surrounded by a cluster of small mounds. It is oblong, with extreme diameter from east to west at the base of three hundred feet, one hundred and fifty feet wide, and is forty-seven feet high. The level area on the summit fifteen by fifty feet is crowded with intrusive burials of a later race. The plate facing page 315, is a good representation of the present appearance of this ancient temple.

The *Sugar Loaf Mound* on Mr. Fay's land, just east of the city line, is built against and upon the side of the bluff, but stands out in bold relief with sharply inclined sides. Diameter from east to west two hundred and sixteen feet, from north to south one hundred and eighty feet, and towering aloft one hundred and forty feet above Vincennes Plain, it commands by twenty-seven feet the high plateau to the east. Area on top sixteen

by twenty-five feet. The following section was developed by sinking a shaft centrally from the top:

Structure of Sugar Loaf Mound.

Loess sand	10 ft. 00 in.
Ashes, charcoal and bones	10 in.
Loess sand	17 ft. 00 in.
Ashes, charcoal and bones	10 in.
Loess sand	9 ft. 00 in.
Ashes charcoal and bones	2 ft. 00 in.
Red altar clays, burned	3 ft. 00 in.
	42 ft. 08 in.

This shaft closely approached or actually reached the former surface of the hill. It settles decisively the artificial origin of the mound, and indicates a temple three stories high.

The *Terraced Mound* on Burnett's land, one mile E. N. E. of Vincennes court house, has an east and west diameter of three hundred and sixty-six feet, from north to south two hundred and eighty-two feet, and rises to an elevation of sixty-seven feet above the plain, with a level area on top, ten by fifty feet. A winding roadway from the east furnished the votaries of the sun easy access to the summit.

The Dicksburg hills, towering like a pyramid one hundred and fifty feet above the surrounding plains, required no additional elevation to secure ample outlook to greet the sunrise, the coming of their deity. The tops of these hills are moulded into shape and covered with sacred and other mounds.

MOUND-BUILDER LAPIDARIES.

Implements of wrought stone so often found elsewhere, were rare. Those seen in private collections exhibited symmetrical forms and a perfection of finish which could scarcely be equalled by our mechanics if deprived of steel implements, the emery wheel and diamond dust. They

consisted of hoes, spades, awls, knives, saws, and spear and arrow points of flint and quartz; axes, chisels, hammers and pestles of drift granite; pipes, beads and ornamental gorgets of greenstone, jasper and carnelian; and plumb-bobs (pendants), made from the specular ores of Missouri; all the last are harder than steel, and indicate a maturity of skill that is never possessed by a "ferocious brute," but is the result of stable society and a considerable degree of civilization.

THANKS.

In conclusion my heartiest thanks are returned to citizens of Knox county for their kind assistance and co-operation. Acknowledgments are due to the following gentlemen for special favors, viz: Messrs. Jno. and Wm. Wise, Hon. H. S. Cauthorn, W. F. Pidgeon, James E. Baker, Messrs. Sheperd and Haslett, Drs. Thomas and Patton, Messrs. Caddington and Noble and Dr. Mantel, at Vincennes; Hon. J. D. Williams, of Pond Creek Mills; Dr. Martin, at Nashville; E. R. Steen and S. L. Niblack, at Wheatland; Messrs. Hill, C. Crane and E. L. Ferguson, at Sandborn; Dr. Keith and A. Simonson, at Edwardsport; Dr. Witherspoon and H. Ball, at Bruceville; and the Drs. Freeland at Freelandsville.

ANALYSES OF KNOX COUNTY COALS.

CURRY COAL L.

Near top of hill at Edwardsport, seam five feet thick, vitreous luster, cubical fracture.

Specific gravity, 1.310. One cubic foot weighs 81.87 lbs.

Coke, - -	61.50	Ash, white, - -	4.50
		Fixed carbon, - -	57.00
Volatile matter,	38.50	Water, - - -	4.00
		Gas, - - - -	34.50
	100.00		100.00

Coke slightly puffed, laminate, vitreous.

This is a superior caking coal, excellent for steam, house use, coking and the manufacture of gas.

WEAVER'S COAL M.

Weaver Coal Company, Donation one hundred and thirty-four, near White river, one mile north of the Ohio and Mississippi railroad.

Specific gravity, 1.277. One cubic foot weighs 79.81 lbs.

Coke, - -	56.50	Ash, brown, - -	4.50
		Fixed carbon, - -	52.00
Volatile matter,	43.50	Water, - - -	5.00
		Gas, - - -	38.50
	100.00		100.00

Coke not swollen, laminate, lusterless.

This is a compact, hard coal, good for steam, household use and for making coke.

WEAVER COAL L.

Donation one hundred and thirty-four, two miles northeast of Wheatland, four feet five inches thick, lusterless, deep black, caking coal, laminæ distinct, without soft carbon partings.

Specific gravity, 1.286. One cubic foot weighs 80.37 lbs.

Coke,	58.00	Ash, red,	5.00
		Fixed carbon,	53.00
Volatile matter,	42.00	Water,	3.50
		Gas,	38.50
	100.00		100.00

Coke slightly puffed, laminate, lusterless.

WEAVER COAL CO., COAL M.

Borings; seam four feet six inches.

Upper part:

Coke,	62.50	Ash, white,	3.50
		Fixed carbon,	59.00
Volatile matter,	37.50	Water	3.50
		Gas,	34.00
	100.00		100.00

Coke puffed, vitreous and amorphous.

Lower part:

Coke,	63.50	Ash, white,	4.00
		Fixed carbon,	59.50
Volatile matter,	36.50	Water,	3.50
		Gas,	33.00
	100.00		100.00

Coke same as upper part.

JOHN HOOPER'S COAL M.

Sec. 22, T. 4, R. 8, caking coal, cubical fracture, 4 ft.

Specific gravity, 1.261. One cubic foot weighs 78.81 lbs.

Coke, - -	58.00	Ash, red, - - -	6.50
		Fixed carbon, -	51.50
Volatile matter,	42.00	Water, - - -	3.50
		Gas, - - -	38.50
	100.00		100.00

Coke slightly swollen, lusterless.

This is a good coal.

DR. KEITH'S COAL K.

Sec. 12, T. 4, R. 8, one-half mile south of Edwardsport. Caking coal, four feet.

Upper part:

Specific gravity, 1.292. One cubic foot weighs 80.75 lbs.

Coke, - -	54.50	Ash, gray, - -	5.00
		Fixed carbon, - -	49.50
Volatile matter, -	45.50	Water, - - -	6.00
		Gas, - - - -	39.50
	100.00		100.00

Coke puffed, amorphous.

Middle part:

Specific gravity, 1.311. One cubic foot weighs 81.93 lbs.

Coke, - - -	55.00	Ash, white, - - -	6.00
		Fixed carbon, - -	49.00
Volatile matter,	45.00	Water, - - -	6.00
		Gas, - - -	39.00
	100.00		100.00

Coke puffed, glossy, amorphous.

Lower part:

Specific gravity, 1.305. One cubic foot weighs 81.56 lbs.

Coke, - -	55.50	Ash, brown, - -	6.50
		Fixed carbon, - -	49.00
Volatile matter,	44.50	Water, - - -	5.50
		Gas, - - - -	39.00
	100.00		100.00

Coke puffed, amorphous.

A good steam coal.

E. W. MC KENNA,

Near Edwardsport; borings, four feet ?

Coke, - -	61.50	{	Ash, white, - -	- 4.00
			Fixed carbon, - -	57.50
Volatile matter,	38.50	{	Water, - -	- 3.50
			Gas, - - - -	35.00
	100.00			100,00

Coke vitreous, not much puffed.

This indicates a good quality of caking coal.

SANBORN COAL K.

Block coal, brilliant, laminate, with soft carbon partings, cleavage lines filled with calc spar.

Specific gravity, 1.287. One cubic foot weighs 80.43 lbs.

Coke, - -	51.50	{	Ash, brown, - -	3.50
			Fixed carbon, -	- 48.00
Volatile matter,	- 48.50	{	Water, - - -	4.00
			Gas, - - -	- 44.50
	100.00			100.00

Coke puffed, brilliant, amorphous.

A fair quality of coal.

So-called cannel coal, a bituminous shale overlying the Sanborn coal K.

Specific gravity, 1.601. One cubic foot weighs 100.07 lbs.

Coke, - -	63.50	{	Ash, brown, - -	25.00
			Fixed carbon, -	38.50
Volatile matter,	36.50	{	Water, - - -	3.50
			Gas, - - -	33.00
	100.00			100.00

Coke compact, unchanged, lusterless.

Contains too much ash to burn freely.

SHEPARD & HAZLETT'S COAL K.

Near Edwardsport, seam six feet, glossy black, laminated, without soft carbon partings.

Specific gravity, 1.304. One cubic foot weighs 81.50 lbs.

Coke, - -	55.50	Ash, blue, - - -	6.50
		Fixed carbon, - -	49.00
Volatile matter, -	44.50	Water, - - - -	5.50
		Gas, - - -	39.00
	100.00		100.00

Coke laminate, slightly puffed, lusterless.

This is an excellent quality of caking coal and will make a good coke.

A. SIMONSON'S COAL L.

Near Edwardsport, five feet thick, caking coal, very glossy, conchoidal fracture, laminæ obsolete.

Upper part:

Specific gravity, 1.250. One cubic foot weighs 78.12 lbs.

Coke, - -	49.50	Ash, fawn, - -	2.50
		Fixed carbon, -	47.00
Volatile matter,	50.50	Water, - - -	3.50
		Gas, - - -	47.00
	100.00		100.00

Coke puffed, glossy, amorphous.

Middle part:

Specific gravity, 1.244. One cubic foot weighs 77.75 lbs.

Coke, - - -	49.00	Ash, fawn, - -	3.50
		Fixed carborn, - -	45.50
Volatile matter,	51.00	Water - - -	3.50
		Gas, - - - -	47.50
	100.00		100.00

Coke puffed, brilliant, amorphous.

Lower part:

Specific gravity, 1.253. One cubic foot weighs 78.31 lbs.

Coke, - -	51.50	Ash, pink, - -	3.00
		Fixed carbon, - -	48.50
Volatile matter,	48.50	Water, - - -	3.00
		Gas, - - - -	45.50
	100.00		100.00

Coke much puffed, amorphous.

This is a good coal for steam, furnace, house use, gas and coke.

SIMONSON & HULAN, COAL K.

Sec. 36, T. 5, R. 8, north of Edwardsport; six feet glossy black caking coal, with cubical fracture and obscure laminæ.

Upper part:

Specific gravity 1.281. One cubic foot weighs 80.06 lbs.

Coke, - -	50.50	Ash, white, - -	5.00
		Fixed carbon, - -	45.50
Volatile matter,	49.50	Water, - - -	4.00
		Gas, - - -	45.50
	100.00		100.00

Coke puffed, vitreous, amorphous.

Middle part:

Specific gravity 1.276. One cubic foot weighs 79.75 lbs.

Coke, - -	52.50	Ash, white, - -	3.50
		Fixed carbon, - -	49.00
Volatile matter,	47.50	Water, - - -	4.50
		Gas, - - -	43.00
	100.00		100.00

Coke slightly puffed, lusterless, amorphous.

Bottom part:

Specific gravity 1.286. One cubic foot weighs 81.00 lbs.

Coke, - -	59.00	Ash, red, - -	7.00
		Fixed carbon, - -	52.00
Volatile matter,	41.00	Water, - - -	3.50
		Gas. - - - -	37.50
	100.00		100.00

Coke slightly puffed, lustreless, amorphous. Excellent coal for steam and domestic use and for gas and coke.

SWICK'S COAL M?

SEC. 23, T. 4, R. 8, near Bicknell on Indian creek. 3 ft. 6 in. seam, a glossy, brownish black, caking coal, with conchoidal fracture.

Specific gravity 1.276. One cubic foot weighs 79.75 lbs.

Coke, - -	51.50	Ash, red. - -	5.50
		Fixed carbon, - -	46.00
Volatile matter,	48.50	Water, - - -	3.00
		Gas, - - - -	45.50
	100.00		100.00

Coke slightly puffed, laminate.

This is a good coal for steam and blacksmith uses.

JAMES D. WILLIAMS, COAL M?

Near Pond Creek Mills, seam 4 ft. thick, analysis from borings.

Coke, - -	58.00	Ash, brown, - -	4.00
		Fixed carbon, -	54.00
Volatile matter,	42.00	Water, - - -	3.50
		Gas, - - -	38.50
	100.00		100.00

Coke slightly puffed, viterous, laminate.

This is an excellent quality of coal.

GEOLOGY

OF

GIBSON COUNTY.

BY JOHN COLLETT.

Gibson county contains four hundred and fifty square miles, and is bounded on the north by Knox and Pike, east by Pike and Warrick, south by Warrick Vanderburg and Posey, and west by the State of Illinois. The Wabash and White rivers form its western and northern boundaries, and the Patoka traverses the county from east to west through the northern parts. These rivers with Pigeon and Black creeks, and their numerous branches, afford drainage and ample supplies of water for stock and other purposes. The surface in the western parts is level or agreeably undulating; about one-half is bottom land and a small portion sand barrens. East of the center and along the eastern and northeastern boundary are elevated plateaus pierced by deep valleys, and covered with excellent timber. The soil is generally alluvial loam and is everywhere fertile. The surface configuration and features are so exactly similar to those of Knox county that discussion under the head of Alluvium, Boulder Drift, and Loess, would be a mere repetition of matters already canvassed in my report on that

county, to which I refer. The only exception will be mentioned, viz:

In the geology of Pike county it is remarked that from the terminus of the conglomerate spur which pierces that county like a promontory from the east, a ridge of yellow loam sets in and continues westward forming the present, as it probably formed the ancient line of demarkation between the waters of Patoka and White rivers. This ridge was clothed with a magnificent growth of oak, poplar and other valuable timber, and, from the quality of its soil, was formed at a time when the head waters of the two rivers were rapidly cutting their channels in the sub-carboniferous limestones to east—constituting a rich calcareous loam. This ridge with like characteristics as to soil and timber is found to be continued from northeast to southwest across Gibson county, constituting a broad belt of the finest agricultural lands in the world about Princeton, Owensville, etc. Outliers of this *Poplar* soil are seen even west of the Wabash, at and southwest of Mt. Carmel, which indicate the wayward course of the river currents then flowing through a broad lake-like sheet of water at an elevation from one hundred and twenty to one hundred and fifty feet above their present channels. The persistence of this ridge clear across, and silting up the previously excavated chasm of the Wabash Valley, will explain the recent existence of a Lacustral sheet of water in Knox county, and the occurrence there of a sub-tropical *fauna* and *flora*, remnants of which linger to this day.*

* *The survival of a sub-tropical flora and fauna*, indicating the existence, at a comparative recent period, of a *member of the "central post glacial lake" and climate is for the first time mentioned* in my report on geology of Knox county. A probable cause is here noted. The extinction of the life of this age has been gradual, long in action, and is still continued. Our mound builders were familiar with tropical life. Their tombs furnish spirited figures wrought in stone of the *Toucan*, *Manatee*, *Puma*, etc., seemingly drawn from life. Within the last thirty years the larger forests of hackberry trees have perished; and within the same time the thousand flocks of Paroquets, whose bright plumage flashing through our forests and odd habits of hibernation were an attractive study to naturalists, have passed away.

The original growth of timber on the uplands consisted of oak and poplar—yards in diameter and rods in length—maple, beech, hickory, ash, gum, etc.; of the river bottoms, walnut, sycamore, cottonwood, papaw, elms, honey locust, cypress, white gum, catalpa, coffeenut and vines. The stations on the railway are among the heaviest lumber marts in the State. Large forests will continue to supply this trade, although one-half are already despoiled, giving place to well appointed farms and comfortable or luxurious homes. The knolls and hill-top uplands in the spring are plumed with bouquets, brilliant with red white and purple promises of fruitage; in autumn the valleys are oderous with the fragrance of ripening orchards.

PALEOZOIC GEOLOGY.

The surface deposits deeply cover the rocks. But few exposures exist, consequently my examinations were limited to a period of twelve days, and the time principally occupied in traveling from one isolated outcrop to another. Fair opportunities for studying the formations were secured along the eastern boundary and just across the line in Pike county. Results gathered from such stations, give the following exhibit, viz:

CONNECTED SECTION OF GIBSON COUNTY.

1.	Soil—Alluvial and Lacustral loams	20 ft. 00 in. to 80 ft. 00 in.
2.	Merom Rock, soft yellow and red sandstone.........	10 ft. 00 in. to 30 ft. 00 in.
3.	Merom Rock, soft heavy bedded sandstone.........	5 ft. 00 in. to 10 ft. 00 in.
4.	Merom Rock, soft massive quarry stone	8 ft. 00 in. to 20 ft. 00 in.
5.	Pyritous shale	00 in. to 5 ft. 00 in.
6.	Irregular coal, in pockets...........	6 in. to 00 ft. 00 in.
7.	Fire clay.............	00 in. to 5 in.
8.	Gray shale...........	5 ft. 00 in. to 10 ft. 00 in.
9.	Flaggy and Quarry sandstone..........	25 ft. 00 in. to 55 ft. 00 in.
10.	Gray silicious shale	31 ft. 00 in.
11.	Shale, with ironstone nodules	2 ft. 00 in. to 00 ft. 6 in.
12.	Bituminous limestone—Fossils...	4 ft. 00 in. to 1 ft. 00 in.
13.	Calcareous shale—clod—Fossils.....	3 ft. 00 in. to 1 ft. 4 in.
14.	Black sheety slate, full of *Discina*, *Lingula*, and *Cardinia*..............	3 ft. 00 in. to 4 ft. 00 in.
15.	Pyritous coal.........	4 in. to 00 ft. 00 in.
16.	Rash coal...........	1 ft. 00 in. to 6 in.

17.	Fire clay..............	4 ft. 00 in. to	6 ft. 00 in.
18.	Shaly flags and sand-rock	8 ft. 00 in. to	16 ft. 00 in.
19.	Hard blue argillaceous limestone.....	15 ft. 00 in. to	8 ft. 00 in.
20.	Place of rash coal...		
21.	Fire clay..............		5 ft. 00 in.
22.	Clay shale, with calcareous nodules, changing at west to limestone	5 ft. 00 in. to	20 ft. 00 in.
23.	Shale and soapstone	25 ft. 00 in. to	2 ft. 00 in.
24.	Black clod–soft slate	2 ft. 00 to	5 in.
25.	*Coal N*................	3 ft. 00 in to	2 ft. 6 in.
26.	Fire clay...............		3 ft. 00 in.
27.	Yellow sandstone and shales, changing at Wabash to limestone	40 ft. 00 in. to	80 ft. 00 in.
28.	*Coal M*, fat caking..	1 ft. 00 in. to	4 ft. 00 in.
29.	Fire clay..............		3 ft. 6 in.
30.	Argillaceous shales and sandstone, changing at the west to limestone	60 ft. 00 in. to	115 ft. 00 in.
31.	*Coal L*, white ash—free burning......	2 ft. 00 in. to	9 ft. 00 in.
32.	Fire clay..............		4 ft. 6 in.
33.	Sandstone and limestone..............	41 ft. 00 in. to	55 ft. 00 in.
34.	*Coal K*...............	2 ft. 00 in. to	4 ft. 6 in.
35.	Fire clay..............		4 ft. 2 in.
			591 ft. 00 in.

Merom Rock.—This sandstone Nos. 2, 3 and 4, of the connected section is found with good exposures along the county line in Township No. 1, ranges 9 and 10. To the south, ascending with the dip, it is soon thinned by ancient denuding forces and is only just caught in the top of the higher ridges and pyramidal hills, as Kennedy Knob near Somerville, and at Snake Knob in Warrick near the extreme southeastern corner of the county. From these points dipping to the west it passes from view beneath heavy deposits of Lancustral and fluviatile loam, until we approach the creek and river valleys, when we find that it has been almost entirely removed by the profound erosive force which was exerted by rushing masses of water at the close of the Boulder drift. Beyond the center of the valley of the Wabash, the dip is reversed, and in Illinois this rock again becomes persistent, where more ferruginous it presented an obdurate bulwark against which the waters of that flood beat in vain. Similar outlying beds are seen at the "Upper" and "Lower Hills" in township 3, S. R. 13, and at "Skelton's Cliff," T. 2, S. R. 12, which rise like artificial pyramids more than one hundred feet above the surrounding bottoms plain. These rocks generally present, in a direction facing the center of the dip, a boldly escarped or overhanging wall, which, tunneled gashed and scarred, records the story of the aqueous conflict, and fully explains the manner in which the valley was excavated. Mouldings and horizontal grooves high up in the sides of the cliff, indicate points where the surface of the lake-like river remained stationary for some time and lashed its waves against the rock islets.

Sections taken at all the outcrops in this county and along the Illinois shore prove by identity of material, stratification and mode of deposit, that these are parts of a single rock which once extended from Merom, the place where first noted, continuously along the Wabash, filling full the valley through which that river has its course; the well cut faces of the stone wherever exposed show that currents of water excavated and removed this belt of sand rock

twelve to fifteen miles wide and nearly one hundred feet thick, on a line more than one hundred miles long. Except at narrow places, bars, etc., the current was evidently sluggish; had only force sufficient to sort out and carry away the finer sands and clays, leaving the *coarser sands* and pebbles to constitute the "Sand Barrens" in the lower end of the county and thence southward. The *Argillaceous* or *Bituminous Limestones* Nos. 12 and 19 are in good force along the eastern line of the county. At Buena Vista they are found well up on the sides of the river bluffs, thence south, depressed for a short distance to the bottom of the ravines, they soon rise against the dip and are only caught in the top of the highest hills as at Hargrave's hill east of Dongola, Kennedy Knob, McGregor Hill, Snake Knob, etc., near the southeast corner of the county. Going west they dip with or faster than the surface deposits, at the rate of about twenty feet to the mile, and at the middle of the Wabash river valley, pass from view below low water mark; but beyond the synclinal axis they again rise to view on the Illinois side.

In the eastern part of the county these limestones are at several points compact and pure enough to burn for lime, and are only separated by a parting of clay a few inches or feet thick. Going west the stone first becomes highly bituminous and the parting is increased, until in the center and western parts, the limestones generally pass into a calcareous clod full of beautifully preserved fossils; the space between is widened up with flaggy sandstone to thirty or forty feet; and each limestone is underlaid by a thin coal or carbonaceous deposit.

The Rash Coals number sixteen and twenty can scarcely be said to have existence in the eastern parts of the county. Generally a mere trace of carbonaceous matter is found over their more persistent fire clays. These are the surface coals at Hazelton, Patoka, Princeton, Owensville, etc., and although sometimes attaining a thickness of one foot, are no where of workable thickness in this State. The flaggy

sandstones number eighteen, are locally heavy bedded and at such stations furnish quarry stone of fair to good quality.

Coal N is a very irregular and inconstant seam. It was identified at a few stations in the southeast part of the county, where it is worked by McGregor and others. The product is a rich gaseous coal, burning with much flame to a white ash.

The sandstone number twenty-seven, superimposes coal M rather persistently, and at many localities presents quarry beds from twelve to twenty feet thick. The stone comes from the quarry soft and light colored, but darkens and hardens on exposure to the air. It has been used with advantage, for foundations piers and hammered masonry. Good exposures are seen near Oakland city.

Coal M.—This seam outcrops and is worked at the foot of McGregor Hill, T. 3, S. R. 8, and is met in wells and on the hillsides north, south and west of Oakland, ranging from two to four and averaging three feet thick. On the northeast boundary it can only be met in deep shafts. The product is a red ash, fat, caking coal.

Coal L.—The mammoth seam of Indiana is grandly developed along and within one to three miles of the eastern boundary, as was noted in Geology of Pike county 1872. It approaches the surface and probably was struck in the town well at Oakland. This seam ranges from three to eleven, averaging over five feet in thickness at the localities mentioned, offering a prime article of white ash, free burning coal suitable for household, locomotive and rolling mill use.

Coal K.—This seam is not visible *in* the county, but is well developed in Pike, from two to four miles east of the common boundary between the two counties, ranging from three to five, and averaging four and a half feet thick. The product is a strong, good grate and steam coal, which burns to a red ash, indicating the presence of some pyrite.

Thus it will be seen that the three great reliable seams of caking coal outcrop at or near the eastern boundary of the county. Thence dipping to the west, they may easily be

won by shafting in the eastern and central areas at a depth ranging from a few feet to one hundred or two hundred feet. In a country of forests where wood is an encumbering annoyance, costing time and money to remove or destroy, coal is not worked—with a small local demand for smiths fires and far away from railways or other lines of transportation, cannot be profitably worked. A ledge of quarry stone or a bank of gravel useful for ordinary purposes is more valuable. This accounts for the fact that little or no coal has been mined or even seen.

According to theories heretofore received these coals dipping far beneath the surface, ought to be found as well in the western parts, accompanied by the companion strata seen at the Pike county outcrops. But bores put down at Princeton, Mt. Carmel and Owensville since my visit (during the autumn of 1873), show, as will be seen under head of local details, 1st, that, the spaces between the seams are widened; 2nd, that the argillaceous and shaly beds are replaced with massive beds of limestone; 3d, that the coals themselves become thin, in a majority of cases too thin to work; and 4th, that the bottom seam K, verging toward non-existence as it approaches the center of the basin, is merely represented by a carbonaceous "clod." These facts and developements, only brought to light within the past few months, show a predominance of limestone unsuspected and unknown before, and indicate a purity of water, necessary for the existence of the marine fauna and corals which make up limestone, but not favorable for the accumulation of thick beds of coal; and explains the reason why the lower coals are not met in deep bores farther west. I have long been satisfied that the marginal coals did not underrun the central areas of extensive basins, but without a consecutive line of bores from the margin to the center no exact law as to the mode of their occurence could be deduced. These bores and other facts heretofore observed although not in sufficient number to establish a positive law, seem to indicate the following generalization; 1st, that the coal seams of the Illinois—Indiana basin, are

only developed in a belt paralell with the margin of the basin; 2nd, that the lowest seam, first to begin among the conglomeratic sandstones at the eastern rim, after attaining a width of twenty five or thirty miles ceases to exist; 3rd, that each succeeding coal commences a few miles still farther within the basin, and after developing the usual breadth of twenty to forty miles, necessarily overlapping its predecessor, ceases to exist.

Accepting this generalization, I would expect to find the upper rash coals, noted as just beginning their existence in this county, to become thicker toward the west and center of the basin, and in local puddles of no very great extent attaining a depth of four or five feet.

To the foregoing discussions of a general nature, local details and sections will be added for home information.

LOCAL DETAILS.

Hazelton, situated on the Evansville and Chicago Railroad, is surrounded by a large body of productive lands It is the market not only for the productions of this area, but also for several fertile townships to the east in Pike county; but the principal business which overshadows all others is the manufacture and preparation of lumber. The first impression felt on stepping from the cars, is that the town is one vast lumber yard. Millions of feet are annually sawed and seasoned for a market that is barely equal to the supply. The timber is brought from the rich uplands on the east side of town, or in huge rafts on White river which flows through its outskirts.

The lower rash coal having a thickness of fourteen inches, was formerly worked (without profit however) in the bed of the river just below town. Covered by full water, it was not visible at the time of my visit, but previously many fossils were found in the limestone clod overlying the coal, including *Bellerophon carbonarius*, *B. Montfortianus*, *B. percarinatus*, *Spirifer cameratus*, *Athyris subtilita*, *Productus longispinus*, *P. semirecticulatus*, *Pleurotomaria tabulata*, *P. spherulata*, a fine *Myalina*, and *Lophophyllum proliferum*. In the river adjoining is found a prodigious mussel, *Unio plicatus*, a valve of which measured nine inches long and six inches wide. One of these was sent by Prof. H. T. Woodman to a skillful polisher of shells in England. The result of this work was magical. The shell was transformed to a mass of silver and pearl, inlaid with black and green mosaics girded about with marginal shadings which reflected every hue of the rainbow.

A bore was put down on Donation one hundred and one, now belonging to Wm. H. Thorn, by Beard, Kerkoff *et. al.*

The following is the common statement of Messrs. Kerkoff and Bridger, who were concerned in the enterprise, and of Mr. Thorn, the owner of the land, to which I prefix a section of the outcrop of the strata which overlie the top of the bore on the same division of land, viz:

HAZELTON SECTION.

(*Donation* 101.)

Soil and slope	
Shaly sandstone and flagstones	10 ft. 00 in.
Yellow sandstone	20 ft. 00 in.
Rash coal	11 in.
Fire clay	2 ft. 02 in.
Shaly limestone	9 ft. 00 in.
Slaty coal	11 in.
Flaggy sandstone to bore	22 ft. 00 in.
	65 ft. 00 in.

HAZELTON BORE.

Soil	4 ft. 00 in.	
Sand stone	40 ft. 00 in.	
Coal N?	1 ft. 00 in.	
Space, sandstone	60 ft. 00 in.	
Coal M	1 ft. 00 in.	
Space, argillaceous sandstone	115 ft. 00 in.	
Coal L.........3 ft. 6 in. to	4 ft. 00 in.	
Sandstone	55 ft. 00 in.	280 ft. 00 in.
		345 ft. 00 in.

Another bore was put down to a depth of about three hundred feet, on the high lands east of town. For the following statement signed by Dr. Wm. Sanders, Charles G. Foot and F. Huffman, I am indebted to the kindness of Mr. J. Zimmerman, of Mt. Carmel, viz.:

EAST HAZELTON BORE.

Drift and clay	25 ft. 00 in.
Hard sandstone (lime stone?)	4 ft. 00 in.
Bituminous shale	6 ft. 00 in.
Silicious shale	25 ft. 00 in.
Soft soapstone	10 ft. 00 in.
Sandstone	40 ft. 00 in.
Bituminous shale	6 ft. 00 in.
Coal	06 in.
Fire clay	6 ft. 00 in.
Sandstone	14 ft. 00 in.
Soapstone	20 ft. 00 in.
Bituminous and silicious shale	15 ft. 00 in.
Coal M?	1 ft. 06 in.
Fire clay and strong water vein which caused the well to cave	4 ft. 00 in.
Soapstone	20 ft. 00 in.
Sandstone	70 ft. 00 in.
Soapstone	40 ft. 00 in.
	307 ft. 00 in.

The thin rash coals outcrop, or are found in wells at several places in the neighborhood, and an opening has been made on H. J. Brown's land, N. W. qr. Sec. 31, but at no point do they exceed eighteen inches in thickness.

I do not doubt that coals M and L will yet be found developing a workable thickness at several points in this vicinity, although the present showing is unfavorable and the search will be attended with many disappointments.*

Ascending White river, an extensive quarry of sandstone is seen two and a half miles east of town. The stone is easily obtained and worked, and is useful for foundations and cellar walls.

*It is hardly necessary to repeat in our reports on every county, that coal seams are never persistant over large areas; horse backs, barren or eroded places occur in the best regulated fields, and som e-times predominate. *Verb. sat. sap.*

Buena Vista, situated on White river, was formerly a shipping point for flat boats, before the free highways on the rivers were vacated for cheaper and more reliable railway transportation. Extensive mounds surround the village which will be hereafter mentioned. Outcrops of the rash coals were observed in the vicinity, and the companion limestones develop a thickness of from two to five feet.

The high ridge and table land south of town, has a rocky skeleton, covered with lacustral loams. But above and against the bluffs of loess are extensive bars or beds of fluviatile sand, a continuance of those noted in the geology of Knox, Pike, Dubois and Lawrence counties, some of which attain an elevation of two hundred and thirty-five feet above the present bed of White river. These indicate the high water level of the ancient river. On the sides of the bluff are occasionally found small beds of gravel, containing a few specimens of the harder stones sorted from the glacial drift, surviving on account of the obduracy of material, but notably containing geodes and cherts from the mountain limestone at the headwaters of the river. The last mentioned, mark the bars or low water line, and plainly indicate the former presence of the river at these points.

A short distance west of the large hickory tree noted in geology of Pike county, the following section was taken; station, 235 feet above White river, viz.:

"BIG TREE" SECTION.

(*Sec.* 7, *T.* 1, *S. R.* 9.)

River sand	20 ft. 00 in.
Fluviatile drift	8 ft. 00 in.
Soft white and yellow sandstone	30 ft. 00 in.
Soft laminated sandstone	22 ft. 00 in.
Quarry sandstone, "Merom rock"	18 ft. 00 in.
Calcaro-argillaceous shale and limestone	10 in. to 3 ft. 00 in.

Black bituminous clod......		1 ft. 4 in.
Rash coal......................	8 in to	2 in.
Fire clay.................. ...		2 ft. 06 in.
Clay shales.....................	6 ft. to	15 ft. 00 in.
Limestone, crinoidal.........	2 ft. to	4 ft. 00 in.
Argillaceous shale............		5 ft. 00 in.
Black slate.....................	3 ft. to	1 ft. 00 in.
Rash coal in branch, report'd		2 ft. 00 in.
		134 ft. 00 in.

Approaching Kirksville we found the little village overwhelmed with affliction. The Asiatic cholera was raging. One entire household, father, mother and children had died. Other families had lost from one to four from their flock. Still, true men and braver women, defying the monster, volunteered to care for the sick, solace the dying and bury the dead. Not willing to admit special dispensations of this kind, I visited the town to inquire whether the calamity should be attributed to natural causes or a providential act. The village is situated upon the eastern bank and partly surrounded by the Patoka, naturally a foul, stinking, rotten river—in summer a solution of decaying vegetable matter, reeking with malarial poison. A dam long maintained, drives the village saw mill, but to intensify the conditions a boom above the dam, not only stopped floating saw logs, but as well the surface current; and the face of the pond was covered with scum and slime, in places thick enough to bear up small animals. Here was a sufficient cause to account for the sallow care-worn, jaundiced faces seen at houses adjoining the pond, inviting the cholera or any other epidemic.

Patoka ought to be drained by the county authorities bordering the whole length of the river, by making cut-offs at the great bends, straightening the channel, and clearing away drift and overhanging timber. The expense would be great; the profits, health, greater.

Near the county line east of Dongola, the limestone accompanying the upper rash coal is well developed. It has been calcined by Mr. Hargrave, near the east line of Sec. 8, Town 2, S. R. 8, furnishing a strong, dark colored lime. At the steam mill in town the following section was noted, viz.:

SECTION AT DONGOLA.

Coarse shelly limestone..................	10 ft. 00 in.
Rash coal and slate......................	1 ft. 06 in.
Gray shale, with ferns...................	1 ft. 08 in.
Slaty coal................................	1 ft. 00 in.
Fire clay.......	2 ft. 06 in.
Impure limestone.	2 ft. 00 in.
Flaggy sandstone.........................	10 ft. 00 in.
Place of coal M..........................	covered.
Space, reported in a traditionary bore	60 ft. 00 in.
Coal L ?.........................	4 ft. 00 in.
	92 ft. 08 in.

South of the Patoka, powerful erosive forces have swept across the eastern part of the county, leaving isolated knobs and hills, monumental tokens of the ancient surface; but generally excavating the rocks to a depth of fifty to one-hundred and sixty feet, and creating broad valleys or valley plains now waterless or used by insignificant brooks. This epoch is dated back to the time of the glacial river, and the soil to the Lacustral, for we find that on the hill sides an ash gray soil prevails, very sensitive to drought or moisture, the modified or washed residual sands of the latter epoch.

Oakland city is pleasanaly situated in a heavily timbered region at the crossing of the proposed "Straight Line" and the L. and St. L. railways. An air of thrift is observed not common at interior towns. From the cupola of Oakland Institute is enjoyed a view ranging over an area of more than six hundred square miles, embracing Olivet

Church and the highlands dividing the watershed of the Patoka from White river seven miles to north. To the east is spread out the beautiful valley basin of South Patoka, enclosed by the conglomerate peaks and hills, which are just seen in the horizon beyond Winslow and Pikeville in Dubois county twenty-two miles distant; southward are Kennedy Knob, Snake Knob and Pidgeon Summit nine miles away; and to the east Harbison's hill within four miles of Princeton.

In digging the Public well near the center of town, at a depth of thirty feet a coal seam was struck Unfortunately a sufficient vein of water was found, and the thickness of the coal was not ascertained. The rubbish thrown out consisting of soapstone and argillaceous sandstone indicates the shales of coal L., which shows in outcrop a mile and a half eastward. A section there taken is subjoined:

SECTION AT MARTIN'S BANK.

Sec 9, *T.* 2 *R.* 8, *W.* (*Pike Co.*)

Soil and clay.................				18 ft. 00 in.
Black slate.....................				1 ft. 00 in.
Soft slate.......................				1 ft. 6 in.
Coal M........................				1 ft. 1 in.
Fire clay......................				2 ft. 7 in.
Silicious shales and soapstone				57 ft. 7 in.
Soapstone—fern bed........			4 ft. to	1 ft. 00 in.
Coal L...........				
Slaty coal......		4 in.		
Laminated coal	2 ft.	6 in.		
Soft black slate		4 in.		
Good smith coal	1 ft.	6 in.		
Clay parting...		2 in.		
Good coal	2 ft.	6 in.		
Rash coal......	2 ft.	00 in.		
	—	—		9 ft. 2 in.
Fire clay......................				4 ft. 9 in.
				— —
				96 ft. 8 in

A valuable stone quarry occurs west of town on the lands of Luster and Keeler, southwest quarter, Sec. 13, T. 2, S. R. 9, where the following section was obtained:

OAKLAND QUARRY.

Soft sandstone...........................	10 ft.	00 in.
Laminated sandstone....................	8 ft.	00 in.
Heavy bedded quarry sandstone containing *Sigillaria, Stigmaria, Calamites*, and *Cordaites*...............	30 ft.	00 in.
Pyritous slate..............................	2 ft.	00 in.
Black slate................................		4 in.
Coal M.....................................	2 ft.	1 in.
Fire clay, to brook....................	4 ft.	00 in.
	—	—
	56 ft.	5 in.

This rock has been quarried to some extent and bears a good character for endurance. Coming soft from the bed it changes to a brown color and hardens; it may be obtained in blocks of great size. Other beds of a similar nature are found occurring in the uplands north and south. Coal M? has been worked by C. H. Wirth on the northwest part of the same quarter section, and is a bright, glossy, fat caking coal, which burns with much smoke and flame, leaving a red ash. An outcrop also occurs on Dill's land adjoining in the same section. On G. S. Vanada's, land southwest quarter, Section 14, T. 2, R. 9, the following outcrop occurs:

SECTION AT VANADA'S.

Soft, yellow sandstone containing *Stigmaria, Sigillaria; Calamites, Cordaites*, etc.,..............................	7 ft.	00 in.
Pyritous slate..............................	1 ft.	01 in.
Coal M......................................	1 ft.	09 in.
	—	—
	9 ft.	10 in.

Continuing west, at A. D. Reavis' farm, a similar outcrop of coal and stone is seen, denoting persistence in the seam and strata.

The surface dips gently to the south from Oakland. In that direction a coal, is found in nearly every well, at a depth of from eighteen to twenty-five feet from the surface, and reported to range in thickness from three and a half to five feet.

COAL IN WELLS SOUTH OF OAKLAND.

Geo. B. Arnold, Sec. 24, T. 2, R. 9, reported...	3 ft. 00 in.
A. Gungel, Sec. 25, T. 2, R. 9, reported.........	5 ft. 00 in.
J. Yeager, Sec, 30, T. 2, R. 9......................	
E. L. Robinson, Sec. 30, T. 2, R. 9...............	
Ed. Gungel, Sec. 36, T. 2, R. 9....................	

Most of these coals are probably L, as the strata rise in that direction, which would bring L nearer to the surface.

At Kennedy Knob, Sec. 35, T. 2, S. R. 9, heavy bands of argillaceous limestone are found near the top of the peak, the companion strata of the rash coals. The coals themselves are absent or not found. The following is the only section attainable:

SECTION ON KENNEDY KNOB.

Sand and Loess..........................	30 ft. 00 in.
Hard argillaceous limestone.	5 ft. 00 in.
Place of upper rash coal................	
Blue fossiliferous limestone............	10 ft. 00 in.
Place of second rash coal...............	
Covered silicious shale..................	35 ft. 00 in.
Coal N.......................................	?
Slope to valley plain.....................	70 ft. 00 in.
	150 ft. 00 in.

An outcrop of the limestone represented in this section, and reported to have a thickness of thirty feet, was not seen. Such developement of a coal measure limestone is extra-

ordinary but not improbable, as a bed of still greater thickness occurs at the same horizon near Marshall, Ills.

McGregor Hill and Snake Knob, near the southeast corner of the county are surviving masses of the former surface rocks, surrounded by valleys of erosion which give them prominence. As at Kennedy Knob, they are capped with the argillaceous limestones accompanying the rash coals, here brought together or separated only by narrow spaces; the rash coals are recognized by their stratigraphic position, their fire clays, and a thin carbonaceous streak. The following section continued along the slope into Pike county, shows the coal and strata which occur in the southeastern part of this county:

SECTION AT M'GREGOR HILL.

(*Section* 9, *T.* 3, *S. R.* 8, *W.*)

Limestone, argillaceous and clinky		6 ft. 00 in.
Clay and shale—place of first rash coal	4 in. to	6 ft. 00 in.
Limestone, compact		3 ft. 00 in.
Shale, with ironstone nodules		4 ft. 00 in.
Place of lower rash coal		
Fire clay		2 ft. 04 in.
Coarse sandstone		8 ft. 00 in.
Silicious shale, bituminous partings		16 ft. 06 in.
Argillaceous shale		8 ft. 00 in.
Black clod—soft slate		2 ft. 00 in.
Coal N—white ash-gaseous		2 ft. 06 in.
Fire clay		3 ft. 00 in.
Silicious shale, and flaggy sandstone		20 ft. 00 in.
Covered space	40 ft. to	20 ft. 00 in.
Coal M	1 ft. to	3 ft. 00 in.
Space, by Barometer	50 ft. to	22 ft. 00 in.

Coal L	2 ft. to 4 ft. 06 in.
Space, by Barometer	30 ft. to 18 ft. 00 in.
Coal K	2 ft. to 5 ft. 00 in.
	163 ft. 10 in.

The argillaceous limerock in the above and Kennedy Knob section, is of great interest as a horizon from which to measure down to the lower coals. Compact and not easily reduced by action of water, it formed at a few stations a bulwark which withstood the ancient currents of erosion. To its protective endurance we owe the existence of the surviving knobs found here and to the south along the divide which separates Ohio and Wabash waters. Going west it dips at the rate of about eighteen feet to the mile, is just caught on the sides and tops of the high hills near Somerville and Buckskin, and descending below the surface is seen in the bed of Muddy Pigeon and its affluents near Fort Branch.

The following is a list of openings or outcrops near McGregor Hill, the banks were not in work and were filled with water; the reported thickness is given:

COALS NEAR M'GREGOR HILL.

J. C. McGregor, N. W. ¼, Sec. 8, T. 3, R. 9	2½ ft. to 3 ft. 00 in.
R. McConnell, S. W. ¼, Sec. 5, T. 3, R. 9	2 ft. to 3 ft. 00 in.
J. K. McGregor, N. W. ¼, Sec. 8, T. 3, R. 9	2 ft. to 2 ft. 03 in.
S. B. McGregor, N. W. ¼, Sec. 8, T. 3, R. 9	2 ft. to 2 ft. 06 in.
J. M. McGregor, sr., N. E. ¼, Sec. 12, T. 3, R. 9	2 ft. 06 in.
Josie Duncan, N. E. ¼, Sec. 7, T. 3, R. 9	2 ft. 06 in.
A. Mason, N. E. ¼, Sec. 5, T. 3, R. 9	2 ft. 00 in.
A. & J. Faris, S. E. ¼, Sec. 5, T. 3, R. 9	2 ft. 06 in.

Near Somerville and Buckskin, the quarry sandstone overlying coal M is found in the foot of the hills and in the valleys; and M is reported in many wells in this vicinity having a thickness varying from two to five feet, at a depth below the surface varying from twenty feet in Fritz's, to fifty feet at Maikran's well.

The only rocky outcrops near Fort Branch and Haubstadt are the rash coals and their companion strata; they are of no economic importance, and only of interest because they fix the geological position of the surface and indicate the great depths at which the lower workable coals must be sought.

Fort Branch, a thrifty village with neat churches, school and business houses, mills, etc., is surrounded by a good agricultural region embracing a variety of soils. To the west "McGarry Flat," a broad belt of rich black land, extending like a river plain north nearly to Princeton and four miles wide, is noted for heavy timber or well improved farms, and substantial farm houses. Blue grass, "the gold finder of Indiana," was observed struggling against and triumphing over neglect, in the waste places and fence corners. A forest of Papaw bushes attracted attention by their tree-like size, being nearly a foot in diameter.

Owensville is surrounded by one of the very best agricultural regions I have ever seen. The soil is a rich calcaro-alluvial loam, producing from forty to fifty-five bushels of corn and from twelve to thirty-three bushels of wheat per acre, proportioned to the care and energy of the farmer. This is a prolongation of the poplar ridge mentioned as dividing the ancient flood waters of White river and Patoka deposited at a time when the latter had its channel, by way of "McGarry Flat," between the town and Fort Branch. The brown and mulatto loams owe their calcareous riches to detrital matter brought from the sub-carboniferous limestones by the former stream. This ridge northwest of town presents a boldly escarped bluff of Merom sandstone on L. Skelton's land, S. W. qr., Sec. 33, T. 2, S. R. 12, where the following section was taken:

SKELTON'S CLIFF.

Soil and fluviatile sand	70 ft. 00 in.
Soft yellow sandstone	10 ft. 00 in.
Massive red and yellow sandstone	12 ft. 00 in.
Brown ferruginous sandstone	8 ft. 00 in.
	98 ft. 00 in.

The face of the cliff is ridged with wave marks, and pierced with rock bores driven by ancient currents which, having removed the main body of the sandrock, left this cliff to to tell the story of the past. From the top of the cliff an interesting view is spread out, ranging over the broad level bottoms to the bluffs in Illinois. To the south the "Upper and Lower Rocks" rise like sharp cones against the sky. The Mound-builders with characteristic appreciation for the picturesque and a wide outlook, erected their tumuli on the summit of the cliff. Choice watermelons are grown on this and adjoining sandy knolls. Mr. Skelton mentioned specimens one to one and a half feet long, weighing from fifty to sixty-five pounds. They are shipped hence to the markets of Chicago, Detroit, Buffalo and New York. The surrounding bottoms grow crops of corn ranging from fifty to eighty-five and averaging fifty-five bushels, and of wheat ranging from twelve to thirty-five and averaging over twenty bushels per acre.

A bore put down by Mr. James Montgomery, who furnishes this statement from the drilling record, developed the following:

SECTION AT OWENSVILLE.

Surface clay	8 ft. 00 in.
Sandstone	2 ft. 00 in.
Rash coal	02 in.
Clay parting	10 in.
Black slate	2 ft. 06 in.
Gray shale	8 ft. 06 in.
Gray limestone	3 ft. 00 in.

Soapstone	3 ft. 00 in.
White limestone	47 ft. 00 in.
Gray shale	29 ft. 06 in.
Black slate	6 in.
Soft, rotten coal	2 ft. 10 in.
Shaly fire clay	4 ft. 00 in.
Gray limestone	30 ft. 00 in.
Gray shale	21 ft. 00 in.
Fire clay	20 ft. 00 in.
Gray limestone	3 ft. 00 in.
Coal	6 in.
Colored clay	2 ft. 00 in.
Hard flinty limestone, with partings	10 ft. 00 in.
Soft, red sandstone	4 ft. 00 in.
Black slate	4 ft. 00 in.
Fire clay and gray shale	10 ft. 10 in.
	217 ft. 10 in.

At the "Dripping Spring," on W. A. Walters' land, N. E. qr. Sec. 33, T. 2, S. R. 12, we find the horizon of the upper rash coal and limestone. The following section was noted:

SECTION AT "DRIPPING SPRING."

Covered, Merom sandstone?	60 ft. 00 in.
Silicious shale	11 ft. 00 in.
Fire clay	4 ft. 00 in.
Argillaceous limestone, containing crinoid stems, *Spirifer lineatus*, *Lophophyllum proliferum* and *Productus semireticulatus*	3 ft. 00 in.
Calcareous clod	2 ft. 00 in.
Shales, covered to bottoms	30 ft. 00 in.
	110 ft. 00 in.

A cluster of mounds on the summit of the hill mark the habitations of our ancient people.

In a well on Sylvester Benson's land, S. E. qr. Sec. 26, T. 2, S. R. 12, the Merom sandstone was found, to which is added the hill side outcrop, viz.:

SECTION AT BENSON'S.

Soil and sand in well	25 ft. 00 in.
Sandstone in well	15 ft 00 in.
(In outcrop.)	
Sandstone	15 ft. 00 in.
Irregular coal	03 in.
Clay	2 ft. 00 in.
Argillaceous shale	14 ft. 00 in.
Bituminous limestone, highly argillaceous	3 ft. 00 in.
Calcareous shale	1 ft. 03 in.
Black bituminous slate—rash coal	1 ft. 06 in.
Fire clay	2 ft. 00 in.
	79 ft. 00 in.

Princeton, the county seat, is pleasantly situated on the Evansville and Chicago railroad, and is surrounded by a gently rolling, fertile region, with bold hills to the east and northeast. It is one hundred and forty-six miles southwest from Indianapolis, and has an elevation of ninety feet above low water in the Wabash at Mt. Carmel bridge, of one hundred and nineteen feet above Evansville, and of four hundred and eighty feet above the level of the ocean.

Thanks are due to Captain Kurtz for the statement resulting from a bore put down under his supervision near town:

PRINCETON BORE.*

Lacustral (or Erie) muck	36 ft. 00 in.
Sandrock	2 ft. 00 in.
Silicious shale	17 ft. 00 in.
Slate and rash coal	1 ft. 00 in.
Fire clay	4 ft. 00 in.
Limestone in bands	15 ft. 00 in.
Soapstone	8 ft. 00 in.
Gray limestone	2 ft. 06 in.
Carbonaceous parting—coal N	02 in.
Fire clay	14 ft. 00 in.
Gray limestone	3 ft. 00 in.
Soapstone	17 ft. 00 in.
Limestone	06 in.
Quarry sandstone	10 ft. 00 in.
Soapstone and gray shale	16 ft. 00 in.
Coal M	1 ft. 00 in.
Fire clay	4 ft. 00 in.
Argillaceous sandstone	12 ft. 00 in.
Limestone	5 ft. 00 in.
Blue shale	55 ft. 00 in.
Blue slate	3 ft. 00 in.
Blue shale	32 ft. 00 in.
Coal L	2 ft. 06 in.
Fire clay	7 ft. 06 in.
Sandrock	9 ft. 00 in.
Carbonaceous clod—coal ?	1 ft. 00 in.
Fire clay	2 ft. 06 in.
Shale and slate	8 ft. 10 in.
Lime rock	7 ft. 00 in.
Shale	2 ft. 00 in.
Black limestone	1 ft. 00 in.
Black slate, place of K	25 ft. 08 in.
	327 ft. 00 in.

*Thanks are due to Wm. Adams, of Paxton, Indiana, practical well borer, for carefully testing with acids, and recording the strata in the wells bored by him at Paxton, Princeton, Mt. Carmel, Owensville, etc.

Coal L. was struck within two feet of the estimate made for its place before the drilling was commenced, proving great regularity in the underlying strata.

Although the seams found in this bore are not of workable extent, nor, judging by samples brought up in the augur tube, of desirable quality; yet the well is richly worth its cost. It proves persistence of the coals in their regular order at least this far west, and shows a strong probability of finding the seams continuously better developed in proportion to the distance, going east from the center of the valley. In other words it favors the presumption that much of the country east of the Evansville and Chicago railroad is underlayed by workable seams of coal. The following bore just completed by Captain Kurtz Sec. 5, T. 2, R. 10, favors this indication, viz:

KURTZ' BORE.

Silicious shale and soapstone...........		30 ft. 00 in.
Sandstone and shales.....................		20 ft. 00 in.
Coal..		trace.
Silicious shales..........................		40 ft. 00 in.
Coal, laminated.......	1 ft. 00 in.	
Clay parting................	1 ft. 06 in.	
Cubic coal..................	2 ft. 00 in.	
Rotten coal.................	06 in.	
	— —	4 ft. 06 in.
Fire clay..................................		2 ft. 06 in.
		— —
		97 ft. 00 in.

At Mt. Carmel, Ills., twelve miles nearly west, a bore in which the strata were carefully tested and recorded by Mr. J. Zimmerman, shows a heavy predominance of limestone, and that the coals are thin or absent. The bore was commenced about thirty feet below the base of the "Merom rock," which outcrops in the Mt. Carmel bluff.

MT. CARMEL BORE.

Shelly sandstone	2 ft. 00 in.
Sandrock	2 ft. 00 in.
Soapstone	4 ft. 00 in.
Sandrock	35 ft. 10 in.
Hard shale	4 ft. 00 in.
Soapstone	1 ft. 00 in.
Black slate coal N	07 in.
Fire clay	9 ft. 00 in.
Sandstone	2 ft. 00 in.
Blue slate	1 ft. 04 in.
Fire clay	3 ft. 10 in.
Limestone	23 ft. 00 in.
Sandstone	1 ft. 00 in.
Limestone	28 ft. 00 in.
Blue slate	5 ft. 06 in.
Soapstone	13 ft. 00 in.
Gray slate	4 ft. 00 in.
Coal M	7 in.
Fire Clay	3 ft. 00 in.
Limestone	13 ft. 8 in.
Fire clay	2 ft. 00 in.
Cherty, limestone with clay partings	10 ft. 00 in.
	169 ft. 4 in.

Bald Hill, two miles north of Princeton, is a lofty knob, which attains an elevation of about one hundred and thirty feet above town or two hundred and twenty feet above the Wabash. Its summit, which was probably rounded into shape by the Mound Builders, affords a wide view over the Wabash and Patoka bottoms. To the west, the houses in Mt. Carmel ten miles distant, and the high ridge at Allendale twelve miles to northwest, are easily recognized. Still more to the north a slight sag in the horizon indicates the trough of the Embarras valley, and beyond, glimpses are caught of the hill tops north and west

of Vincennes. To the east, the upper valley of the Patoka opens a vista toward sunrise reaching well into Pike county.

On the lands of C. Myers adjoining, the following outcrop is seen:

MYERS HILL SECTION.

Slope—covered		70 ft. 00 in.
Merom sandstone		29 ft. 00 in.
Black sheety shale		1 ft. 4 in.
Pyritous clod		9 in.
Coal (irregular)		7 in.
Fire clay	5 ft. to	3 ft. 6 in.
		105 ft. 2 in.

Near Severn Bridge on the northwest bank of Patoka, Section 23, T. 1, R. 10, the rocky strata are locally depressed, and thickened up to such a degree as to afford quarry beds similar to those east of Hazelton near the horizon of the rash coals. The stone is laminated, varying from thin flags to heavy or massive beds. It is a grayish yellow color, and hardens on exposure, weathering brown. Patoka bridge piers, built thirty two years ago, afford a fair and satisfactory test of its enduring qualities. The following section commences at the top of the quarry hill and is continued across the river to the south, so as to include lower strata there brought to view by irregularities in the ancient surface:

TOWNSEND QUARRY SECTION.

Soil	10 ft. 00 in. to	14 ft. 00 in.
Heavy sandstone		5 ft. 00 in.
Rash coal and slate		8 in.
Fire clay		1 ft. 2 in.
Heavy bedded and flaggy sandstone		30 ft. 00 in.
Shaly sandstone		10 ft. 00 in.

Gray shale...........		31 ft. 00 in.
Nodular iron ore.....	2 in to	6 in.
Bituminous limestone		1 ft. 00 in.
Calcareous shale, Argillite		1 ft. 4 in.
Black sheety slate...	3 in.	6 in.
Rash coal.............		6 in.
Fire clay to Patoka..		9 ft. 00 in.
		104 ft. 8 in.

In Sections four and five, Town 2, Range 10, this section is continued to the lower rash coal, viz:

SECTION NORTHEAST OF TAFFTOWN.

Bituminous limestone with *Productus semireticulatus*, *P. longispinus*, *Athyris subtilita*, *Chonetes*, *Cardinia*, *Spirifer Kentuckensis*, *Machrocheilus*, and *Pleurotomaria*, ...	1 ft. 6 in.
Calcaro-argillite with some fossils.........	1 ft. 2 in.
Black sheety slate, with *Pectens*, *Lingula*, *Discina*, *Crania*, *etc*..........	3 ft. 00 in.
Pyritous clod.........	10 in.
Rash coal, (upper)...	1 ft. 00 in.
Fire clay.........	4 ft. 00 in.
Fire clay, with iron stone nodules......	6 ft. 00 in.

Gray shale...........		5 ft. 00 in.
Hard argillaceous limestone...........	3 ft. 00 in. to	8 ft. 00 in.
Fire clay—place of lower rash coal....		5 ft. 00 in.
Gray shale............		10 ft. 00 in.
		45 ft. 4 in.

The seam in this section has been worked by Capt. Kurtz, Mr. Carnahan and Mr. Harmon, and although thin, affords a bright lustrous coking coal, containing enough pyrite to cause disintegration on exposure. The following fossils were seen in the slaty roof of the coal, at Kurtz's bank, N. E. qr. Sec. 5, T. 2, S. R. 10, viz.: *Nucula inflata*, *Chonetes Verneuilanum*, *Leda bellistriata*, *Athyris subtilita*, *Orthoceras Rushensis*, *Bellerophon carbonárius*, *B. Montfortianus*, *Pleurotomaria tabulata*, *P. spherulata*, *P. Grayvillensis*, *Macrocheilus primigenius*, etc., and crinoid columns.

Patoka, situated upon the river from which it takes its name, at the crossing of the Evansville and Chicago Railway, is a thrifty manufacturing town. The extensive distilleries of Bingham Bros. consume large amounts of corn and manufacture great quantities of highwines, etc.

The locality is favorable on account of the comparative absence of lime and other minerals so common in the Western streams. The whole valley of the Patoka, fifty miles long, sends the choice of its forests to this town for manufacture, and immense quantities of lumber are produced. Generally the Patoka, near this place, is covered for miles with saw logs rafted or floated from Pike and Dubois counties, and justifies to this day the Indian name.*

Below the mill the following outcrop occurs, viz.:

*Patoka, the Miami (Piankashaw) name, means "The crooked river, filled with logs."

SECTION AT PATOKA.

Loess, ash gray.................		15 ft. 00 in.
Loess, reddish..................		5 ft. 00 in.
Covered, Merom sandstone...	5 ft. to	10 ft. 00 in.
Slaty coal.........................	5 in. to	1 ft. 02 in.
Gray shale and flaggy sandstone.........................		40 ft. 00 in.
Bituminous limestone or clod with *Productus longispinus*, *P. costatus*, *Nucula inflata*, *Spirifer cameratus*, *S. Kentuckensis*, *Macrocheilus primigenius*, *Bellerophon carbonarius*, *B. Montfortianus*, *Pleurotomaria spherulata*, *Lophophyllum proliferum*, etc..............................	2 in. to	08 in.
Argillite with fossils..........		2 ft. 00 in.
Black slate, with *coprolites* and *fucoides*..................	2 ft. to	4 ft. 00 in.
Blue shale........................	3 ft. to	4 ft. 06 in.
Coal, rash		07 in.
Fire clay..........................		3 ft. 00 in.
Hand argillaceous limestone changing to buff silicious shale............................	2 ft. to	4 ft. 00 in.
Fire clay, place of lower rash coal		2 ft. 06 in.
Soapstone, with iron nodules		5 ft. 00 in.
Laminated sandstone to river		1 ft. 00 in.
		98 ft. 05 in.

The place or horizon of coals M and L, is from one hundred and seventy-five to three hundred and fifty feet below the bed of the stream, and the probable thickness ranges from nought to three feet.

ECONOMIC GEOLOGY.

The peculiar formation of the surface deposits endow this county with a variety of fertile soils, and insures a diversity of pursuits so necessary for the social, pecuniary and political welfare of a community. In the western half recent alluvial bottoms prevail, and crops of corn, potatoes and grass are produced equal in yield to the most favored locality. The ancient delta of the White and Patoka rivers in the northern and central areas, presents a gently rolling or knolly surface, beautiful and at the same time desirable. This part is fertile in a superalative mood, producing large crops of wheat, oats, grass, etc. The southeastern division although not so fertile, is of average quality and is clothed with forests of valuable timber.

It may not be improper to suggest that with long continued cropping the best of lands will deteriorate. The present generation ought not to impoverish the soil and rob the future. Rest, rotation and clover, expedients now scarcely thought of, would maintain or support this element of wealth.

The "Sand Barrens" in the southwestern part of the county have their special value. On this soil, worthless to ordinary agriculture, melons, sweet potatoes, etc., of superior size, excellent flavor and in immense quantities are produced: they are shipped by rail to the principal cities of the nation.

DRAINS AND LEVEES.

The bottoms are subject to overflow, and in part are swampy or covered with ponds. It is a well settled axiom

with engineers, that evaporation will remove ordinary rainfall from a plat of land, if flood waters are kept away. A system of levees erected under competent direction, would reclaim large areas, double the income of the people, and to a considerable extent prevent malarial diseases. The State of Illinois with wise outlook for the future, exempts for a limited time from taxation, lands which are being so improved. This example is worthy of consideration by our own legislature.

WELLS.

Springs are not common, but water is obtained in wells of moderate depth; as is usual, such water leached through alluvial sands will dissolve and contain disagreeable or deleterious minerals. In all such—in almost every case, it is safest to rely upon the pure water which falls from the heavens. Secured in cisterns, rain water is cool and pleasant, and its use causes a marked absence of inflammatory diseases.

TIMBER.

The extent and giant size of the original forest has been heretofore mentioned. Immense quantities of the most valuable timber, as poplar and walnut, was used by the pioneer for rail fences or destroyed by burning; then a toilful encumbrance; which if preserved to this day, would bring more money than the present value of land and improvements. An extraordinary growth of ash was noticed near Owensville. In this vicinity Mr. W. A. Walters has measured trees having a circumferance as follows: Poplar trees eighteen feet, Black walnut eighteen feet, Sycamore twenty-four feet, Catalpa nine to twelve feet Sassafras seven to nine feet, and Maples (Sugar trees) thirteen feet.

In the White river bottoms opposite Hazelton, Mulberry trees were seen which measure from six to seven feet, Cypress seven to ten feet, Apple trees seven feet, and a Sassafras seven feet five inches in circumference. Near the same locality in Knox county, Mr. R. E. Starnate says that

Catalpa trees two and a half to three feet in diameter are common, that he has measured one four and a half feet, a Persimmon *bush* two feet, and a Sycamore seven feet in diameter. Col. Cockrum, Sr., of Oakland, mentioned a Catalpa four feet in diameter.

DURABILITY OF CATALPA TIMBER.

This timber is universally accredited with a wonderful power to resist decay and time. Experience is limited to the early settlement of the county little less than one hundred years, but I could find no one who was willing to say that the catalpa wood was liable to rot. Tests made at Vincennes and Decker station are memtioned in the report on Knox county. Col. Cockrum has known it in use without stain of decay for fifty years; and Capt. Kurtz knows Catalpa trees dead, but still standing in the overflowed bottoms of the Wabash, which were killed by the ice in the great January flood of 1828. Oakland Institute is covered with Catalpa shingles, but if steamed and cut, this process will injure their enduring qualities. The growth of a timber having these qualities should be encouraged. If found suitable for ties it ought to command the attention of persons in direction of railways, and thus secure a solution of the great railway problem of the near future. The tree is of rapid growth, offensive in odor and taste is not liable to be destroyed by animals, flourishes best in overflowed lands, and the trunk by measurement increases in diameter from one-half to three-fourths of an inch per annum.

STONE.

Stone suitable for building purposes is not common. The "Merom Rock" is generally friable, and will soon disintegrate on exposure. Fair quarry stone is found east of Hazelton, at Severn bridge on Patoka, and near the county line in Township No. 1, S. R. 9, all from the space between the rash coals. Stone indicating superior quality is found in the vicinity of Oakland.

COAL.

Coal of excellent quality in abundance, sufficient to supply any possible demand, it will be seen, occurs along the line which separates this from Pike county. The indications observed promise that seams K, L, and M, with an average thickness of over four feet each, may be found generally underlying the eastern half of the county—subject to the interruptions by erosion, horse backs, and barrens, which are found to exist in the best regulated coal fields. Test bores sunk during the past fall and winter, at the center and western part of the county, show that these seams although persistent, are there usually thin, pyritous, rarely of workable extent, and only found at a depth ranging from two hundred to four hundred feet. Within this district workable seams however, will occasionally be found, but the search will be attended with much cost and many disappointments.

CLAY.

Bricks of good quality are made in all parts, and material is abundant. All the coals are underlaid, and the places of the barren seams, occupied by fire clays, which in the future will equal the coals in value. These clays are suitable for the manufacture of tiles, terra-cotta and potters' ware, fire brick, etc., and will found extensive manufactories.

METALLIC ORES

Are not found in this county. Indian tradition to the contrary is false. Native gold and galena imported by the boulder ice, have been found in small lots in wells near the center of the ancient trough of the Wabash; the former in nuggets weighing from two to three grains.

ROAD MATERIAL.

Gravel for roads was not seen in quantity. Careful search will probably discover beds of this valuable and necessary material in the old terraces in the "bottoms" of the

Wabash and White rivers. If not so found, gravel and stone may be imported by rail or river transportation.

HEALTH.

The use of pure rain water for household and culinary purposes has already been earnestly advised. Bilious diseases and the effects of malaria may be in a great measure avoided by arranging sleeping chambers not less than ten to twenty feet above the surface of the earth. This truth is proverbial throughout the old world. Even animals respect it and seek their nightly rest on knolls and hill tops. Stairways or even ladders are cheaper and sweeter than quinine.

TRANSPORTATION AND MARKETS.

The Evansville and Chicago Railroad traverses the county from north to south, through the center, and the Wabash river, navigable during a portion of each year, forms the western boundary; these afford quick and direct communication with the great markets in the region of the lakes and the Mississippi valley, and indirectly with all the world. The Louisville and St. Louis Railroad is in process of construction, and it is believed will, within the coming year, open a direct outlet for the surplus products to the East or West.

FRUIT AND VINEYARDS.

The advantages found to exist in Knox, appertain in a superlative degree, to Gibson county. Nature has planned here at the center of the continental fruit belt a "pomological paradise," by adding to the genial climate a generous soil, and offers to reward persistent effort with rich harvests. Grapes are fully matured, and ripen sweet and fragrant. The Concord, Ives' Seedling, and Norton's Virginia, are favorite bearers. Wine, prepared by a skillful artist at Mt. Carmel, is considered by experts to fairly rival the famous brands of Rhineland.

ARCHÆOLOGY.

The tops of some of the knobs or peaks have been modeled by the Mound-builder; on many their small tumuli are still found, as at the Upper and Lower Lone Rocks, Skelton's Cliff, the Dripping Spring, etc. Extensive loess knolls at Buena Vista are surmounted by sacred mounds of great size; but intrusive graves of a later race are found at the surface near the summit. All the points mentioned combine the elements found necessary for the Mound-builders' civilization, viz.: productive farm lands, available springs, picturesque scenery and a wide outlook, embracing signal stations and confederate towns, miles away in the horizon.

THANKS.

Thanks are returned to Judge Hanna, of Petersburg; Capt. Kurtz, Mr. Harman, Mr. Mitchell and others, of Princeton; the Cols. Cockrum, of Oakland, for information, guidance and assistance; to Prest. Ingle, for transportation on the Evansville and Chicago Railroad.

GIBSON COUNTY COALS.

FINNEY'S COAL.

Three miles east of Princeton, seam one foot thick, mined by W. C. Harmon, dull black caking coal.

Specific gravity, 1.307. One cubic foot weighs 81.86 lbs.

Coke, - -	58.00	Ash, brown, - -	6.50
		Fixed carbon, -	51.50
Volatile matter,	42.00	Water, - - -	6.00
		Gas, - - -	- 36.00
	100.00		100.00

Coke slightly puffed, lusterless, amorphous.

A moderate quality of grate coal.

JOHN MC GREGOR'S COAL N.

Sec. 8, T, 3, R. 8, seam two feet six inches thick, glossy black, caking coal, laminated structure.

Specific gravity, 1.249. One cubic foot weighs 78.06 lbs.

Coke, - -	56.00	Ash, yellow, - -	3.50
		Fixed carbon, -	52.50
Volatile matter,	44.00	Water, - - -	4.50
		Gas, - - -	- 39.50
	100.00		100.00

Coke puffed, amorphous, brilliant.

A fair quality of coal.

OAKLAND CITY COAL L ?

A dull, slaty looking coal, found by sinking a public well; five feet thick?

Specific gravity, 1.391. One cubic foot weighs 86.93 lbs.

Coke, - -	62.00	'Ash, red, - -	18.50
		Fixed carbon, -	43.50
Volatile matter,	38.00	Water, - - -	6.00
		Gas, - - - -	32.00
	100.00		100.00

Coke, laminated, lusterless, not swollen.

This is probably mixed with a portion of the roof shale.

G. S. VANADA'S COAL M.

Two miles west of Oakland; seam one foot, nine inches thick, glossy black coal, laminated structure.

Specific gravity, 1.275. One cubic foot weighs 79.68 lbs.

Coke, - -	59.50	Ash, red, - - -	5.50
		Fixed carbon, -	54.00
Volatile matter,	40.50	Water, - - -	5.00
		Gas, - - -	35.50
	100.00		100.00

Coke slightly puffed, amorphous, brilliant.

A moderate quality of caking coal.

TRIPOLI.

The following highly interesting paper on the Tripoli found in the cavities of the cherty limestone overlying coal seam K, near Ferdinand, Dubois county, Ind., and prepared for sale by the Anderson Valley Mining Company, has been kindly furnished by Dr. Jos. Gardner, whose skill as a microscopist is worthy of special note, since this material was submitted to other eminent microscopists, who were unable to find in it any trace of organic remains.

An account of the manner of preparing and use of this Tripoli will be found in Prof. Collett's report on Dubois county, p. 228, 3d vol. Geology of Indiana, 1872.

PROFESSOR E. T. COX:

State Geologist:

DEAR SIR:—The specimen of "commercial tripoli" sent me, the label of which stated that it was from the "pockets" in the cherty limestone, forming the roof of coal K, in Dubois county, has been submitted to microscopic examination, and I offer the following statement:

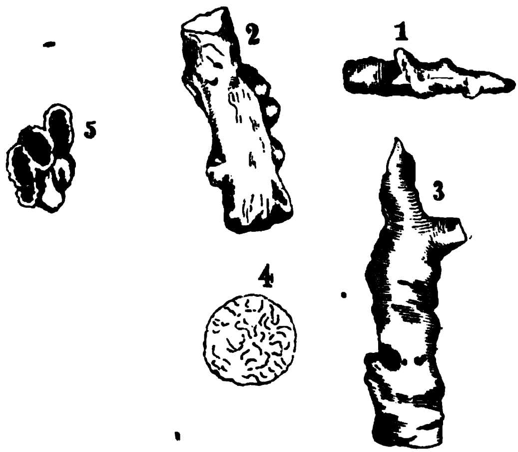
Tripoli is chemically allied to both the flints and sandstones. The ordinary tripoli of commerce consists of

Silicic acid	90. per cent.
Alumina	7. per cent.
Oxide of iron	3. per cent.

That from Dubois county appears to have about this composition. Its buff color is due to the presence of oxide of iron.

Tripoli differs from sandstone and sharp sand more in physical than in chemical constitution.

In sandstone the particles have been arranged according to the general laws governing the crystallization of inorganic bodies. Tripoli, on the contrary, has for its basis the silicified skeletons of organic bodies.



The figures 1, 2, 3 and 4, in the above cut, represent the prevailing forms of these skeletons, magnified about three-hundred and fifty diameters. Nos. 1 to 3 are *spicules* having a more or less cylindrical form and generally terminate in a point. On some, may be seen, small tubercles or rudimentary branches and others show where the developed branches have been broken off.

Figure 4 shows a transverse section ot one of the cylindrical *spicules*, as broken off.

Figure 5 is a fragment of a *forameniferous* shell.

The general character of the remains, in this specimen of tripoli, shows that it is made up almost exclusively of the skeletons of sponges; these skeletons may have been, during the existence of the compound animal that formed the sponge, either the hornlike substance, called *chitine*, of which the claws, stings and other parts of insects are composed, or built up of carbonate of lime, deposited by the animal, like the shells of mollusks; or, they may have been

formed, like many of the sponges of the present age, of silicic acid with traces of iron and other elements. Sponges are found in the Caribbean sea, composed wholly of silica, and are as flexible as spun glass.

I incline to the opinion that the animalculæ, that secreted the *spicules* found in tripoli, deposited them with very nearly their present chemical composition. I have examined many other remains and find, in almost every instance, that where the original elements have been replaced by silica, the crystalline character demonstrates conclusively that such was the case. This has not been found true of any tripoli, examined, from Dubois county,

In the chert, flint or hornstone of Lawrence county I find a somewhat similar form of *spicules*. They are found imbedded in the mass of flint and by chipping off scales from translucent masses they may be perceived by careful handling. The nodules of flint picked up in the neighborhood of the chert beds have had their neuclei made up of sponges, and I have been so fortunate as to find one of these nodules which, on being broken open, shows the root by which the sponge was attached, and in a cavity, near its centre, I found a slight net work of the glassy filaments of the sponge, which under the micrescope, leaves no doubt of their origin. These filaments retain their flexibility and are readily separated from the parent mass. When mounted for examination under the microscope, and viewed, either as opaque or transparent objects, they are both beautiful and instructive.

It may be safely asserted that almost all the hornstone nodules found in chert are fossil sponges. It is hardly necessary to add that sponges grow only beneath the surface of water, and that there are both salt and fresh water varieties.

Yours Truly,

JOS. GARDNER, M. D.

Bedford, Ind., Dec. 1873.

ANALYSIS OF COALS—KNOX COUNTY.

County.	Name of Mine or Owner.	Specific gravity.	Weight of one cubic foot.	Fixed Carbon.	Ashes.	Coke.	Gas.	Water	Total Volatile Matter.	Color of Ash.
Knox	Curry ... L	1.319	81.87	57.00	4.50	61.50	34.50	4.00	38.50	White.
Knox	Hooper, John ... M	1.261	78.81	51.50	6.50	58.00	38.50	3.50	42.00	Red.
Knox	Keith, Dr., upper ... K	1.292	80.75	49.50	5.00	54.50	39.50	6.00	45.50	Gray.
Knox	Keith, Dr., middle ... K	1.311	81.93	49.00	6.00	55.00	39.00	6.00	45.00	Gray.
Knox	Keith, Dr., lower ... K	1.305	81.56	49.00	6.50	55.50	39.00	5.50	44.50	Brown.
Knox	McKenna ...			57.50	4.00	61.50	35.00	3.50	38.50	White.
Knox	Sanborn ... K	1,287	80.43	48.00	3.50	51.50	44.50	4.00	48.50	Brown.
Knox	Sanborn, (cannel coal) ... K	1.601	100.07	38.50	25.00	63.50	33.00	3.50	36.50	Brown.
Knox	Shepard & Hazlett ... K	1.304	81.50	49.00	6.50	55.50	39.00	5.50	44.50	Blue.
Knox	Simonson, A., upper ... L	1.250	78.12	47.00	2.50	49.50	47.00	3.50	50.50	Fawn.
Knox	Simonson, A., middle ... L	1.244	77.75	45.50	3.50	49.00	47.50	3.50	51.00	Fawn.
Knox	Simonson, A., lower ... L	1.253	78.31	48.50	3.00	51.50	45.50	3.00	48.50	Pink
Knox	Simonson & Hulan, upper ... K	1.281	80.06	45.50	5.00	50.50	45.50	4.00	49.50	White.
Knox	Simonson & Hulan, middle ... K	1.276	79.75	49.00	3.50	52.50	43.00	4.50	47.50	White.
Knox	Simonson & Hulan, lower ... K	1.286	81.00	52.00	7.00	59.00	37.50	3.50	41.00	Red.
Knox	Swick ... M ?	1.276	79.75	46.00	5.50	51.50	45.50	3.00	48.50	Red.
Knox	Williams, J. D ... M ?			54.00	4.00	58.00	38.50	3.50	42.00	Brown.
Knox	Weaver Coal Company (borings) ... M ?			59.00	3.50	62.50	34.00	3.50	37.50	White.
Knox	Weaver Coal Company ... M	1.277	79.81	52.00	4.50	56.50	43.50	5.00	48.50	Brown.
Knox	Weaver Coal Company ... L	1.286	80.37	53.00	5.00	58.00	38.50	3.50	42.00	Red.

ANALYSES OF COALS—WARREN COUNTY.

County.	Name of Mine or Owner.		Specific gravity.	Weight of one cubic foot.	Fixed Carbon.	Ashes.	Coke.	Gas.	Water	Total Volatile Matter.	Color of Ash.
Warren	Briggs, Jno	K	1.212	75.75	48.50	2.00	50.50	44.75	4.75	49.50	Flesh.
Warren	Briscoe, J. T., upper	L	1.223	76.44	57.50	7.00	64.50	32.00	3.50	35.50	Gray.
Warren	Briscoe, J. T., middle	L	1.267	79.18	54.70	8.00	62.70	33.80	3.50	37.30	Blue.
Warren	Briscoe, J. T., lower	L	1.350	84.37	52.25	16.00	68.25	28.75	3.00	31.75	Blue.
Warren	Claypool, R. W., upper	L	1.246	77.87	48.50	10.00	58.50	38.50	3.00	41.50	Red.
Warren	Claypool, R. W., middle	L	1.204	75.87	55.50	2.50	58.00	38.00	4.00	42.00	White.
Warren	Claypool, R. W., lower	L	1.205	75.31	54.50	8.50	63.00	34.00	3.00	37.00	Brown.
Warren	Claypool, R. W	M			48.00	3.50	51.50	45.00	3.50	48.50	Brown.
Warren	Goodrick	M	1.343	83.93	45 00	9.50	54.50	39.50	6.00	45.50	Red.
Warren	Goodrick, upper	L	1.304	81.50	46.50	8.50	55.00	42.00	3.00	45.00	Purple.
Warren	Goodrick, lower	L	1.262	78.87	46.00	4.50	50.50	46.50	3.00	49.50	Flesh.
Warren	Hooper & Barringer, upper	L	1.238	77.37	59.00	2.50	61.50	34.50	4.00	38.50	White.
Warren	Hooper & Barringer, lower	L	1.236	77.25	56.00	2.50	58.50	35.00	6.50	41.50	White.
Warren	Harold & Co., upper	L	1.282	80.15	54.00	6.50	60.50	36.00	3.50	39.50	Red.
Warren	Harold & Co., lower	L	1.252	78.25	56.00	3.50	59.50	31.00	9.50	40.50	White.
Warren	Harold & Co., middle	L	1.290	80 62	49.50	7.50	57.00	38.50	4.50	43.00	White.
Warren	Jarvis, upper	K	1.243	77.68	50.50	6.50	57.00	38.00	5.00	43.00	Red.
Warren	Jarvis, middle	K	1.251	78.18	53.50	3.00	56.50	40.75	2.75	43.50	White.
Warren	Jarvis, lower	K	1.348	84.25	51.50	12.00	63.50	33.00	3.50	36.50	White.

ANALYSES OF COALS—WARREN, GIBSON, CLAY COUNTIES, AND OTHER LOCALITIES.

County.	Name of Mine or Owner.	Specific gravity.	Weight of one cubic foot.	Fixed Carbon.	Ashes.	Coke.	Gas.	Water	Total Volatile Matter.	Color of Ash.
Warren	Luppoldt, upper ... L	1.222	76.37	49.00	9.50	58.50	37.00	4.50	41.50	Red.
Warren	Luppoldt, middle ... L	1,254	78.37	52.50	9.00	61.50	33.50	5.00	38.50	Red.
Warren	Luppoldt, lower ... L	1 256	78.50	57.00	4.50	61.50	35.50	3.00	38.50	White.
Warren	Schoonover, upper ... K	1.284	80.25	49.40	9.50	58.90	37.60	3.50	41.10	Red.
Warren	Schoonover, lower ... K	1.229	76.81	55 25	6.25	61.50	34.00	4.50	38.50	Red.
Warren	Thomas, Jno ... M	1.415	88.43	49.50	12.50	62.00	33.50	4.50	38.00	Red.
Warren	Tinker & Co., upper ... L	1.257	78.56	50.00	3.50	53.50	43.50	3.00	46.50	Red.
Warren	Tinker & Co., middle ... L	1.282	80.12	47.00	3.00	50.00	44.50	5.50	50.00	Blue.
Warren	Tinker & Co., lower ... L	1.244	77.75	50.50	5.00	55.50	42.50	2.00	44.50	Red.
Gibson	Finney ...	1.307	81.68	51.50	6.50	58.00	36.00	6.00	42.00	Brown.
Gibson.	McGregor ... N	1.249	78.06	52.50	3.50	56.00	39.50	4 50	44.00	Yellow.
Gibson	Oakland City, upper ... L?	1.391	86.93	43.50	18.50	62.00	32.00	6.00	38.00	Red.
Gibson	Vandalia, G S ... M	1.275	79.68	54.00	5.50	59,50	35.50	5.00	40.50	Red.
Clay	Markland Mining and M'f'g Co. ...	1.211	75,69	52.00	2.00	54.00	41.50	4.50	46.00	White.
State Missouri.	Benj. Ruffner, Link mine ...	1.318	82.37	55.00	7.50	62.50	30.50	7,00	37.50	White.
State Missouri.	Benj. Ruffner, Upsom mine ...	1.074	67.12	55 50	2.00	57.50	36.50	6.00	42.50	White.
Tennessee	McGill's Gulf, Chattanooga ...	1.345	84.06	65.00	9.50	74.50	23.00	2.50	25.50	White.
Tennessee	Soddy mine, Chattanooga ...	1.283	80.18	75.00	4.00	79.00	17.50	3.50	21.00	Red.
Colorado	Canon City ...			53.00	4.50	57.50	38.00	4.50	42.50	Yellow.

PROF. E. T. COX:

State Geologist:

DEAR SIR:—In compliance with your letter of instructions of 8th April, 1873, I proceeded to the northern part of the State and made examinations and collected statistics and other available information in the counties of Dekalb, Steuben, Lagrange, Noble, Elkhart, St. Joseph and Laporte, and herewith respectfully submit my report on the same.

A letter was, also, addressed to the chief officer of each Railway company having a road, wholly or in part, in Indiana, north of the Wabash river, requesting a copy of the *profile* and *section*, of that part of the road lying in this State, sent to your office. The Lake Shore & Michigan Southern Railroad Company promptly complied with the request. Letters were received from four other companies stating that they did not possess any such data. The remainder are yet to hear from.

Cordially thanking you for your kindness, I remain,

Yours truly,

G. M. LEVETTE.

INDIANAPOLIS, IND., 1st March, 1874.

REPORT OF OBSERVATIONS

MADE IN THE COUNTIES OF

DEKALB, STEUBEN, LAGRANGE, ELKHART, NOBLE, St. JOSEPH AND LAPORTE.

BY G. M. LEVETTE.

The above counties lie wholly within the Boulder Drift or Quaternary epoch, and are covered with transported material to a great depth. Bores have been put down at different points in the northern part of the State, some of which reached the underlying limestone rock, of the Devonian age, at a depth of eighty-eight feet, while others have gone to the depth of two hundred and twelve feet all the way through glacial clay.

A well was sunk at Fort Wayne, and reached the limestone, (upper Silurian) at eighty-eight feet. At the town of Elkhart, about fifty miles northwest of Fort Wayne, a well was bored to the depth of one hundred and twenty-five feet, and stopped among small boulders without reaching the bed rock. About twenty-five miles west of this, at South Bend, near the St. Joseph river, three wells were sunk, varying in depth from ninety-two to one hundred and three feet. Having secured the desired artesian flow of water, none of these reached the underlying rock. Still

further west, about twenty miles, at New Buffalo, in the State of Michigan, near the Laporte county line, the Michigan Central Railroad Company bored a well to the depth of two hundred and twelve feet and reached the rock at that point. A few miles west of this, at Michigan City, within the grounds of the Northern Indiana Penitentiary, a well has been bored to the depth of five hundred and forty-one feet, one hundred and seventy-two, of which, were through the sand and clay of the Boulder Drift.

Excepting the bore at Michigan City no detailed record could be procured, of any of the deep wells within the counties named; yet the general statement regarding each well, whether made by parties who done the boring or those who paid for it, that "it was nearly all clay, a little sand or gravel on top, and now and then a boulder," develops the fact that the great bulk, more than nine-tenths, of the material of the boulder drift over the northern part of the State, is a stiff tenacious clay, with boulders and pebbles irregularly scattered through it, and with occasional partings of sand and gravel. At some points this clay has become very hard and is known among miners and well borers as "hard-pan." It is perfectly impervious to water and serves as the puddled bottom of nearly all the beautiful lakes scattered throughout the counties named.

At South Bend the wells reached a stratum of water which rises to the surface and flows in steady streams, but not with any great force. The wells stop in a bed of small boulders which, probably, rest on the underlying stratified rock. Other wells have been sunk to the same horizon without reaching a supply of water. It is not, therefore, a uniform source of supply; though the success at South Bend is encouraging and their example a worthy one to those who desire a steady flow of water.

That these enormous deposits of material, equal in solid contents to a small range of mountains, and covering the whole of northern Indiana, the southern part of Michigan and the northwest part of Ohio, to an average depth of, perhaps, a hundred feet, were brought down from points

north of the great lakes by the agency of glaciers, moving fields of ice, or icebergs floating in a sea which then covered the whole Mississippi valley from the Polar Ocean to the Gulf of Mexico, is now almost universally accepted by geologists as a fixed and incontrovertible fact. The glacial hypothesis of Prof. L. Agassiz, with slight modifications, explains in a rational and satisfactory manner all the conditions existing in this section of country.

The decomposition by atmospheric agencies, and the homogeneous mixture of the great variety of materials constituting the Boulder drift, gives to this section, a soil unsurpassed in productiveness, and being unbroken by abrupt hills or deep ravines, it has offered great attractions to those who would migrate from the thickly populated communities and worn out soil of the eastern states, to some more favored spot where a home could be secured with less outlay of time and capital.

The general surface of the country is rolling, but nowhere can it be called hilly. About one-third of the territory included in these counties was originally covered with heavy timber which has been, until recently, unsparingly destroyed. The remainder being either "oak openings," as they are called, or prairies, with a few swamps and innumerable small lakes. The "oak openings" are sparsely covered with a stunted growth of white or burr oak. The soil of the prairies and "openings" is lighter, containing more sand than that of the timbered lands. Each character of soil is particularly adapted to the more perfect growth of some special crop, and when a single farm of a few hundred acres encloses the loamy clay soil of the timber, the sandy loam of the prairie, the lighter sand of the "openings" and the arenaceous muck of the drained swamp, the fortunate cultivator possesses decided advantages over more specialized localities.

On the eastern side of the district, the land, originally timbered, is largely in excess of prairies and "openings," but as we go west the proportion of prairie lands increase until on the western margin of the State the forests are

limited in extent and the prairies cover much the larger portion of the territory.

All the counties named, are bountifully watered by lakes and numberless small rills and creeks which join, one with an other, and form important tributaries of some of the large and well known streams of this and adjoining states.

In the northeast corner of the State the land is, comparatively, high and the small streams, in the eastern half of the county of Steuben and the whole of Dekalb, are tributary to the Maumee river, which flows into Lake Erie; while those in the northern part of the counties of Steuben, St. Joseph, and nearly the whole of Lagrange and Elkhart, find their way into the St. Joseph river and thence to Lake Michigan. In Noble county, the small streams having their rise in the northeast corner, separate, some flowing eastward into the Maumee, some northward into the St. Joseph, and others in a southerly course into Eel river, and thence through the Wabash and Ohio rivers into the "Father of Waters." This would indicate a high crest or divide, in this region, but such is not the case; the Grand Rapids & Indiana railroad passes directly over this watershed without appreciable grades or deep cuts.

In the southwest corner of Elkhart and in the southern part of St. Joseph and Laporte counties the streams join the Kankakee river and, by the circuitous route and sluggish current of that stream, become tributary to the Illinois river and flow thence to the Mississippi. Some small streams, in the north part of Laporte county, flow directly into Lake Michigan. No plunging rapids or precipitous falls occur in any of these streams. Those in the eastern counties do not have a sufficient flow of water to furnish power worthy of note. The Elkhart and St. Joseph rivers have a very gradual and continuous fall, and where dammed, at Goshen, Elkhart, Mishawaka and South Bend, furnish in the aggregate, several thousand horse power throughout the whole year. Large manufacturing establishments are in operation at these points, and others are in

course of construction, the details of which will be more fully given under the heads of the respective counties.

This is eminently an agricultural district; but little capital being invested in manufacturing, except at the above named towns, where the hydraulic power has been utilized. The soil is easily brought from a "state of nature" to that of productive cultivation, is very fertile and yields bountiful crops of all the grains, grasses and fruits usually grown in this latitude and climate.

The following is a list of the timber trees found in this part of the State, and are named in the order of their abundance:

Beech	*Fagus ferruginea.*
White oak	*Quercus alba.*
Burr oak	*Quercus macrocarpa.*
Black oak	*Quercus nigra.*
Red oak	*Quercus rubra.*
Sugar-tree	*Acer saccharinum.*
Elm	*Ulmus americana.*
Poplar	*Liriodendron tulipifera.*
White ash	*Fraxinus americana.*
Blue ash	*Fraxinus quadrangulata.*
Hard maple	*Acer rubrum.*
Pignut hickory	*Carya sulcata.*
Black ash	*Fraxinus sambucifolia.*
Shellbark hickory	*Carya alba.*
Basswood	*Tilia americana.*
Black walnut	*Juglans nigra.*
Cherry	*Prunus pennsylvanica.*
Sycamore	*Platanus occidentalis.*
Sassafras	*Sassafras officinale.*
White walnut	*Juglans cinerea.*
Tamarack	*Larix americana.*
Cottonwood	*Populus monolifera.*
White pine	*Pinus strobus.*
Coffee-nut	*Gymnocladus canadensis.*
Red cedar	*Juniperus virginiana.*
Box elder	*Negundo aceroides.*

This order of arrangement is an approximation deduced from opinions given by lumber dealers and land owners in various sections of the district visited, and though nearly correct now, would have been widely at fault before the great demand for lumber for furniture and general manufacturing, had drawn so largely on the supply of walnut, ash and hickory.

Considerable deposits of bog iron ore, peat and marl are found in the marshes and low grounds and near the lakes, in some localities, a more complete account of which will be given in treating of the counties separately.

Through lines of railway have been constructed, between the east and west and the north and south, over this territory, so that almost every acre is within easy distance of some depot where all the products of the soil, forest or factory may be disposed of, for cash, at ruling market prices.

Scattered over these counties are some hundreds of lakes, varying from a few acres to several square miles in superficial area, and from a few feet to many fathoms in depth. In some instances these are fed by small streams which gather and pour into them the drainage of the surrounding country. Springs, issuing from the gravel and sand, are not uncommon along their margins. Some of these lakes have no visible outlets, while others are connected, one with another, by flowing streams and through similar outlets become tributary to neighboring creeks and rivers. They are very generally stocked with an abundance of fish, which furnish an easily obtained and wholesome article of diet to all who care to avail themselves of the privilege of taking them.

These crystal sheets of water not only offer rare attractions for boating, fishing and gunning, but lend ever varying charms to the beautiful landscape of which they form a part; and whether viewed as they lie unruffled in the haze of an Indian summer sun, or lashed to foaming fury by the passing storm, or when clasped cold and lifeless in the

embrace of winter, they are objects of unceasing interest; only awaiting the pen of a Cooper or Willis to give them well deserved fame and immortality.

The bountiful educational provision, for which Indiana has long been proverbial, is brought to the full measure of its usefulness in this part of the State. That popular fountain of universal education—the Public School—is here held as a sacred trust, entailed to the ever-rising generation by the wise founders of the system, and is, alike, free to all without regard to color, sex or nationality.

Many of the pioneers, the first to follow the Indian trail into an almost trackless waste of prairie, lake and forest, are still living on the same tracts of land which their well directed toil and perseverence has transformed from primitive wildness to luxurious homes, adorned with all the appliances of modern civilization.

A marked degree of intelligence, thrift and enterprise characterized the people in all the districts visited. Neat, comfortable, vine-clad homes meet the eye at every turn. Villages and towns have sprung into existence at convenient intervals, where school houses and churches indicate the trend of public sentiment. The citizens have availed themselves of the progressive spirit of the times and gathered about them the comforts and luxuries of an advanced civilization, and on every hand is seen the evidences of a high degree of culture and refinement.

While prosecuting investigations, and traveling in the counties enumerated at the head of this paper, I was placed under great obligations, for information, attention and courtesies, to many of the citizens, among whom I will name the following:

William McIntire, County Auditor and A. S. Hollowpeter, of Auburn; G. W. Baxter, editor of the "Express," and Wes. R. McBride of Waterloo, Dekalb county.

Hon. W. J. Howard, G. Brown, County Clerk, F. W. McCartney, Dr. G. W. McConnell, John A. Cowan and Dr. W. C. Weicht, of Angola, Steuben county.

J. P. Jones, Recorder, Isaiah Piatt, Auditor, J. H. Rerick, County Clerk and editor of the "Standard," and Col. Dodge of "Brown's Hotel," of Lagrange, Lagrange county.

Hon. William Bunyan and James Colgrove of Kendalville, Nelson Prentiss and S. E, Alvord, editor of the "New Era," of Albion, Noble county.

Hon. J. R. Beardsley, C. H. Chase, editor of the "Review," R. K. Brush, editor of the "Observer," D. W. Sweet, editor of the "Union," of Elkhart; J. A. S. Mitchell, C. Hawks, M. B. Hascall, editor of the "Democrat," W. M. Starr, editor of the "Times," of Goshen, Elkhart county.

Honorable Lucius Hubbard, A. B. Miller, Editor of the "Tribune," A. Beal, Editor of the "St. Joe Valley Register," and T. G. Turner, of South Bend, St. Joseph county.

John Sutherland, President of the Indiana State Board of Agriculture, Dr. T. Higday, Sims Major, Editor of the "Herald," and H. E. Wadsworth, Editor of the "Argus," of Laporte, and Hon. F. H. Winterbotham, H. H. Walker, W. W. Higgins, Mayor, Captain E. Bennett, C. Mayne, Warden of the Penitentiary and C. A. Manning, Deputy Warden, of Michigan City, Laporte county.

DEKALB COUNTY.

Dekalb county is bounded on the north by Steuben, on the east by the state of Ohio, on the south by Allen county and on the west by Noble. This county was organized in 1836, and named in honor of Baron DeKalb, a patriotic German who espoused the cause of the American Colonies in their struggle for Independence.

The county contains 3,690 square miles. At the time of its organization the population was but little over 1,000. In 1870 it numbered 17,167. It was originally settled by

a small colony of Germans, from Pennsylvania, who have since been reinforced by brethren from the Fatherland.

The surface is neither level nor hilly, but sufficiently undulating to insure good drainage. The soil is good and well adapted to growing cereals and grasses.

Not many years ago this county was covered with a heavy forest, much of which has been destroyed in clearing the land for tillage; and the great and constantly increasing demand for lumber for building and manufacturing purposes is rapidly depleting it. Among the desirable timber trees are found White, Black, Red and Burr Oaks, Hard and Soft Maples, Hickory, Elm, Ash, Black Walnut, Cherry, Beech, Sycamore and Cottonwood. Quite an important trade is carried on in the manufacture of staves and headings of red and black oak and shingles from other timber. The great demand for black walnut, for furniture and finishing purposes, has drawn heavily on the original bountiful supply of that timber, and at the current rate of consumption many of the present citizens of the county may live to know it as the rarest and most costly of indigenous timber trees.

The St. Joseph-of-the-Maumee furnishes a limited amount of water power, three flouring mills are run by water on that stream. Several steam flouring and saw mills are in operation in other parts.

The surface is well watered on the eastern side by the St. Joseph-of-the-Maumee and its numerous small tributaries, and on the western side by Big and Little Cedar creeks which join in Allen county and flow into the St. Joseph. By this it will be seen that this county lies wholly on the eastern side of the dividing ridge, or water shed, that separates the streams which flow into Lake Erie and eastward from those which flow into the Wabash river and thence to the Gulf of Mexico. The water in the streams has a smoky color, owing to the presence of organic matter taken up from the peat beds, which are not uncommon, along the water courses in this part of the State.

Wells, sunk to the depth of eight to twelve feet, reach a

stratum of water slightly colored but palatable, yet too "hard" for laundry purposes; by sinking the wells fifteen feet further a second stratum of water is reached which is clear, cold and "hard" and in some instances slightly chalybeate; tube wells are often introduced to reach this second supply and when they are driven twenty feet further, or about forty-five feet from the surface of the ground, another stratum is found, clear but often strongly chalybeate, In the neighborhood of Auburn, the county seat, the water of the lower stratum rises in the wells nearly to the surface of the ground, and eastward of that town it is sometimes artesian.

A superior article of clay is found in various parts, free from gravel and which makes durable bricks of a uniform texture and good color. An abundance of brick clay, and the present low price of fuel compensates in a manner, for the entire absence of building or paving stone in this county.

Dekalb is traversed in an east-west direction by the Lake Shore & Michigan Southern railroad; in a north-south direction by the Fort Wayne, Jackson & Saginaw railroad and in a northeast-southwest course by the Detroit, Eel River & Illinois railroad, and in an east-west direction by the Baltimore, Pittsburg & Chicago railroad, thus affording ample transportation, in all directions, for the products of the soil and forest, and direct communication for the citizens, with the Capital of the State and all the important cities of the country.

A few of the citizens are engaged in converting the timber into merchantable forms, but with these exceptions and the necessary percentage of mechanics to supply and keep in repair the machinery and various mechanical adjuncts of an enlightened and progressive agricultural community, the population of this county devote themselves to tilling the soil.

Auburn, the county seat, is a thriving town of about one thousand inhabitants and is situated near the geographical centre, at the crossing of the Fort Wayne, Jackson &

Saginaw, and the Detroit, Eel River & Illinois railroads. The only other considerable town and commercial point in the county is Waterloo, six miles north, where the Lake Shore & Michigan Southern, and the Fort Wayne, Jackson & Saginaw railroads cross each other, and contains about fifteen hundred inhabitants.

I could not learn definitely of any mounds in the county, though stone axes, flint arrow heads, spear points, scrapers and other relics of the Mound Builders have been picked up on the surface, which would indicate that this strange people had at least hunted over this territory, though, perhaps the land in this region was, during their reign, too low and marshy to afford inviting sites for the erection of their time defying temples.

STEUBEN COUNTY.

Steuben county is in the extreme northeast corner of the State and is bounded on the north and east by the States of Michigan and Ohio, on the south by Dekalb county, and on the west by Lagrange. It was first settled by a small colony from Ohio in 1833, which has since been steadily augmented by immigration from New York and New England. The county was organized in 1837, and named in honor of Baron Steuben, a foreigner, who rendered efficient service as a general in the Federal Army during the Revolutionary War. The first census after the organization, indicated a population of two thousand five hundred and seventy-eight, which had increased to twelve thousand eight hundred and fifty-four in 1870. It contains about three hundred and thirty-five square miles and has its surface gently broken by small hills, though nowhere so much as to prevent cultivation. The general surface is considerable higher than that of Dekalb, the next county

south, the surface gradually rising from the south line to about the middle and is nearly evenly divided between timber lands, "oak openings" and sandy prairies.

The timbered lands have a heavy clay soil, which is very productive and noted for the great crops of wheat and grass which it yields. The prairies and "oak openings" are quite similar in character being sandy and light, and, in the first settlement of this part of the State, were considered less productive than the heavier soils, and rather neglected until a denser population brought all the lands into requisition, when more careful attention and comparison developed the fact that the "oak openings" equalled any other soil in the district, producing most excellent crops of all the cereals and grasses. The northern part is noted for large orchards which rarely fail to yield good crops of superior winter apples which are shipped to less favored localities.

The surface is well watered by Pigeon, Crooked and Fish creeks and their numerous small tributaries, none of which are of sufficient volume to furnish water power of any note. A number of lakes are scattered over the county, ranging from a quarter of a mile to five miles in length. Thirty-five of them are named:

Balls, Bass, Belle, Cedar, Center, Clear, Crooked, Cross, Fish, Fox, Gage, George,* Golden, Goose, Hog,* Hogback, Howard, Island, James, Jimerson, Lime, Lime-kiln, Little Turkey, Long,† Loon, Marsh, Mill, Mud, Otter, Pigeon, Pleasant,* Silver, Tamarack, Turkey and Walker.

In addition to these there are several smaller lakes known only by the names of the owners of the farms on which they are located.

All these are bountifully stocked with several species of fish which furnish the tables of the citizens with cheap, delicate and nutritious food. Among the fish taken, and perhaps the most abundant in these lakes, is the justly celebrated western game fish—the Bass, (*Centrarchus fasciatus*,—DeKay.) which is to the western angler what the

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* Partly in Michican.

† Partly in Ohio.

salmon and speckled trout are to the Waltonians of the Eastern States. The water is usually clear. In some instances the shores are abrupt with the forest growing to the edge of the gravelly terrace; others are approached over a gradually declining beach of clean sand and gravel. Some are very deep, while a few, called "grass lakes" are shallow and are being gradually filled up by the growth of marsh grass and water plants around the edges. During the seasons of migration, spring and autumn, great numbers of water fowl alight here for food and rest, usually remaining but a few days, with the exception of a few individuals of the smaller species which stay all summer and breed.

The land owners of this county are awake to the importance and value of their forests in which may be found White, Black and Red Oak, White Walnut, Ash, Beech and Maple, with some Sycamore and Tamarack.

Bog iron ore has been found in the edges of a few of the marshes, but nowhere in sufficient quantity for profitable working.

Peat occurs in parts of the county and may, when the surrounding country has been denuded of its present stock of firewood, be dug and dried, or condensed and formed into convenient sizes by machinery, and used as fuel. On the shores of some of the lakes are beds of marl, several feet in thickness, made up of small fresh water shells and earthy matter. Up to the present time its use as a fertilizer has been very limited, but its benificial effects is acknowledged by those who have tried it. Marl dug from these local deposits and burned, is a passable substitute for lime for building purposes, though not a rival of the famous Huntington and Peru brands. Before railroads were constructed through this section of the country, builders were compelled to haul lime a long distance or resort to this inferior local substitute. Its chief value will be as a fertilizer when the soil shall have been worn thin by long tillage.

Easily accessible deposits of most excellent brick clay occur in many parts of the county.

Agriculture is the chief occupation of the citizens, who are worthy representatives of the energy, thrift and intelligence which characterized their New England ancestors.

Saw mills, flouring mills, foundries, machine and other shops are scattered over the county as determined by the wants of an agricultural people.

The Fort Wayne, Jackson & Saginaw railroad crosses about the centre of the county in a north—south direction. The Chicago & Canada Southern railroad has been graded across the southern edge of the county in a east—west course.

Angola, the county seat, is a thrifty town, of about twelve hundred inhabitants, on the line of the Fort Wayne, Jackson & Saginaw railroad and is the centre of a fertile and highly cultivated district. Other thriving towns are located in the county, though the county seat is the principal commercial centre. A few small mounds are known. Just east of Pleasant lake the outlines of two can be distinctly traced; no one seemed to know whether either of them had ever been opened. On the north shore of Silver lake, twenty feet above the water, are five mounds, the largest about twenty feet in diameter and three to five feet high; some years ago J. W. Gale, with two or three friends, opened one of these and found human bones, but no stone implements. In the southwest corner of the county on the north shore of Little Turkey lake are ten small mounds. Dr. W. C. Weicht was one of a party who dug into one of these some years ago, no implements or pottery, but six different layers of human bones were found, distinctly separated by thin strata of earth; the skeletons lay on their backs, extended full length. This mound was about ten feet in longer diameter and six feet in the shorter, by five feet high.

It is doubtful whether these bones were those of any older race than the American Indians, yet it is strange that the elevated surface and dry soil of this district, with its alternations of dense forest and open or thinly wooded

prairie, and its numerous lakes, well stocked with fish and water fowl, did not offer that lost race—the true mound builders—sufficient attraction to induce them to attempt a defense of this aboriginal Eden, with some of their large and remarkable earth-works.

LAGRANGE COUNTY.

Lagrange county is bounded on the north by the State of Michigan, on the east by Steuben county, on the south by Noble and on the west by Elkhart. It was organized in 1832 and named after the country seat or villa of General Lafayette, in France. It was originally settled by New Englanders, since which time many Ohioans and Pennsylvanians have moved in. In 1840 the inhabitants numbered three thousand six hundred and sixty-four; in 1870 the census returned a population of fourteen thousand one hundred and forty-eight. The county is twenty-four miles from east to west, sixteen and a half from north to south, and contains three hundred and ninety-six square miles.

In some parts the surface is gently rolling while in others it is quite hilly, and all, except a few small marshes, is susceptible of easy cultivation. Nearly one-half of the area was originally covered with dense forests on a heavy clay soil which, when brought under cultivation, yields good crops of the grains and grasses; the remainder is mostly "oak openings," with two or three small prairies, the soil of which is a light, sandy loam, easily cultivated and generously rewards the toil of the husbandman.

On the south side of Pigeon river, extending in a northwest and southeast course, from near the eastern boundary of the county to the marshes on the western side, is a belt of sand, varying from one to three miles in width. In the southern part, near the Noble county line, is a ridge of sand,

thirty to forty feet high and from one hundred to one hundred and fifty feet wide, called the "Hog-back." It is less than one mile long and extends from the low land, at its eastern end, in a westerly direction, to the hills where it disappears.

The soil and climate here are favorable to the cultivation of the apple; orchards look well and rarely fail to yield good crops, and thousands of barrels of winter apples are annually shipped to eastern markets.

The cranberry thrives on the peaty soil around the marshes in this part of the State; there are several large "patches" in the western part of the county. The universal popularity of this fruit renders its cultivation a certain source of revenue; considerable quantities are annually shipped to market.

In the forests are found Red, White and Black Oak, Poplar, Smooth and Shell-bark Hickory, Hard and Soft Maple, Beech, Elm, Ash and Tamarack; White and Black Walnut were once plenty, but have been thinned out within the past few years.

The northern and central parts are watered by Pigeon river and its tributaries. The river flows across the county, passes out at the northern boundary, where it enters the State of Michigan and becomes tributary to the St. Joseph. Elkhart river runs in a northwest direction across the southwest corner of the county. Several beautiful lakes occur, among which are: Adams, Atwood, Blackman, Cedar, Cotton, Eve, Fish, Grass, Lake of the Woods, Little Turkey, Long, Mott, Olin, Oliver, Pretty, Shipshewana, Stone, Turkey, Twin Lakes, Wall and Wilmer, and a number of others too small to be dignified with names on the county map.

Here, as elsewhere throughout the northern part of the State, these lakes form an attractive and picturesque foreground to the landscape, and, from the windows of the swiftly gliding railway coach, occasional glimpses of prairie, lake and woodland arouse the weary traveler to look again upon the passing picture.

No extensive manufacturing is carried on here, a few flouring mills, saw mills, foundries, machine and other shops are located at different points over the county.

Clay, suitable for the manufacture of brick, is abundant and is a first-class article as attested by an inspection of those used in the construction of buildings in and about the county seat.

Bog iron ore is found in considerable quantities in the marshes, along Pigeon river, west of Lima. About the year 1850 a forge was started at Lima and worked this ore into bar iron, a very fair article was made which commanded a good price. The ore being difficult of access, and fuel (charcoal) increasing in price, the forge was abandoned about the time the Lake Shore & Michigan Southern Railroad placed this part of the country in quick and cheap communication with the iron manufacturers of Cleveland and Pittsburg.

Large deposits of peat occur in some of the marshes on the western border.

The Lake Shore & Michigan Southern Railroad crosses in an east-west direction. The Grand Rapids & Indiana Railroad passes through in a north-south direction, and the Chicago & Canada Southern is partly graded across the southern border.

Lima was the seat of Justice from the organization in 1832, until 1844, when it was moved to its present site in the town of Lagrange, nearer the geographical center. Lagrange is on the line of the G. R. & I. R. R., and has a population of over one thousand two hundred; it is the largest town in the county, though Lima and Ontario are thrifty rivals.

The section of high, undulating, lake-dotted country, of which Lagrange county is a part, does not seem to have been the home, or even the haunt, of any considerable number of the Mound-builders. One small earthwork is all that is known in the county; that is on Brush prairie, in the eastern part. It is about fifty feet across, nearly circular and raised two feet above the surface of the prairie;

near the center is a small mound, about eight feet in diameter and three feet high. An excavation made in this central mound, some years ago, exposed decaying human bones, some broken pottery and a few stone implements.

NOBLE COUNTY.

Noble county is bounded on the north by Lagrange, east by Dekalb, south by Allen and Whitley and west by Kosciusko and Elkhart counties. The first settlements made within these limits were by emigrants from Ohio and Pennsylvania. At this time nearly every State east of Indiana, is represented in this attractive agricultural district.

The county was organized in 1836 and named in honor of Noah Noble, then Governor of the State. It contains four hundred and twenty square miles and had in 1840, at the time of the first census, a population of two thousand seven hundred and two. Its steady and healthy growth is indicated by the census of 1870, showing a population of twenty thousand three hundred and eighty-nine. The surface is diversified with hills alternating with burr oak "openings" and about evenly divided between the two; many small prairies occur and one of several thousand acres near Ligonier, in the northwest corner of the county. The soil of the timbered land is loam and clay with a stiff clay subsoil and is proverbially productive. That of the "burr-oak openings" is lighter, containing sand, is easily cultivated and is considered the best in the county. The soil of the prairie is a dark peaty loam and sand with a subsoil of gravel or sand. Corn, wheat, oats and the grasses are grown to great perfection, and apples and other fruits amply reward the attention their cultivation has received. Peat bogs or marshes occur at intervals some of which

appear to have been lakes now bridged over by the growth of aquatic plants, marsh grass and shrubbery; a few of them have become densely covered with small trees and underbrush, the tough roots of which, interlacing with each other, have strengthened the treacherous bridge and give the surface the appearance of enduring solidity. In several instances, in the northern part of the State, railroads have been constructed across these apparently solid meadows or wooded marshes which after a short term of use have sunk below the established grade, and in some cases broke through the surface crust, necessitating the construction of a temporary route around the marsh. Adding earth or gravel to the sinking road bed, to keep it up to a proper grade, increases the weight until the sinking burden has reached the bottom of the old lake and rests upon a solid foundation. In every case, thus far, these "sink holes" have been bridged over on piles driven into the solid earth, or filled by hauling in gravel until the road beds are safe. In no case was the sinking so sudden as to cause the loss of life or merchandise in transit.

White Oak is the most abundant timber tree; Red, Black and Burr Oak, Hickory, Poplar, Elm, Maple, Ash, and Beech, are still plenty; White and Black Walnut and Coffee-nut occur sparingly and Tamarack is seen in some of the swamps.

The northern part of the county is watered by the Elkhart river and its tributaries, the eastern part by numerous small tributaries of the St. Joseph-of-the-Maumee, and the southern part by some branches of Eel river. Near Lisbon in the northeast corner, is the summit or crest from which the streams run northwestward into Lake Michigan, eastward into Lake Erie and southwestward into the Wabash river.

The monotonous succession of gently undulating surface is charmingly diversified by numerous lakes, some of which are set in the emerald green of surrounding forests, while others reflect from their zephyr rippled surfaces the golden harvest of cereals grown upon the surrounding lands.

The citizens claim that this county contains more than one hundred lakes. The following are named on the county map: Bixler, Bottle, Crane, Deep, Deer, Diamond, Eagle, Engle, Latta, Long, Marl, Muncie, Round, Sand, Sanford, Sap, Silver, Skinner, Sparta, Tamarack, Tippecanoe, and Waldron, and a chain of twenty small lakes in the southeast corner.

But little manufacturing is carried on here, and we find only such shops, mills and factories as are necessary to supply the needs of an exclusively agricultural community.

The Lake Shore & Michigan Southern railroad passes through in an east-west direction; the Grand Rapids & Indiana railroad crosses in a north-south course, and the Baltimore, Pittsburg & Chicago railroad is in course of construction in an east-west course, passing near the county seat.

Albion, the capital, is situated near the geographical centre and is a thriving town of nearly one thousand inhabitants. Kendalville, in the northeast part, at the crossing of the Lake Shore & Michigan Southern and Grand Rapids & Indiana railroads, is the largest town in the county and an important commercial centre of a fertile and highly cultivated district. Ligonier, the second in size,is west of Kendalville on the Lake Shore & Michigan Southern railroad; it is a place of marked thrift and enterprise and numbers about two thousand inhabitants. Rome city, Wawaka, Brimfield, Lisbon, Avilla, Walcottville and Rochester are all promising towns, entertaining metropolitan hopes which time and well directed energy may enable them to realize.

Extensive beds of bog iron ore occur. The largest deposit is on Ore Prairie in the western part. It lies in the edge of the marsh about one foot beneath the surface, is about twenty feet wide and from four to eight feet thick.

In 1845 Messrs. French & Beers erected a Catlin forge, for reducing this ore, at Rochester on the Elkhart river in the northwest corner of the county. About the time the

Forge was completed, and before it was put in operation, the original proprietors sold to W. F. Lee of Mishawaka in St. Joe. county, A. D. Webster of Rochester, N Y. and D. M. Beers of Newtown, Conn., who put the forge in blast, employing about sixty men in digging and hauling ore, burning and hauling charcoal and working the forge. About four hundred bushels of charcoal were burned in making one ton of bar iron from three tons of ore. The product was ten tons of bar iron per week which was sold at one hundred dollars per ton. Ore diggers, colliers and common laborers were paid fifty cents per day and boarded, while "bloomers" and "hammers-men" received two dollars per day and board. The tract of land on Ore Prairie from which the ore was dug, was then owned by Hon. Henry L. Ellsworth, of Lafayette, Ind., who received a royalty of twelve and a half cents per ton for all ore taken out. The firm continued in the business until the spring of 1850, when they sold to Wood & Bromley of Lagrange who carried it on a few years and abandoned the enterprise.*

Immense deposits of peat occur in the lower lands, along the marshes and over the "bridged lakes." A partly completed "fill" of the Baltimore, Pittsburg & Chicago railroad broke through the crust of a subterranean lake, a half mile west of the town of Albion, and exposed a deposit of peat eighteen feet in thickness. Fish with perfect eyes and the colors common to the species, came up with the water, on the submerged embankment, clearly indicating that this hidden lake was somewhere connected with water exposed to the rays of the sun.

In the dim, distant future when the wants of a dense population shall demand the cultivation of every available foot of this fertile section of country and fuel shall have become the costliest item of household economy, these deposits of peat will be sources of wealth to the owners and

* For the above data am I indebted to Nelson Prentiss Esq., who was book-keeper for the Forge Co.

objects of practical interest to those who consider the success and well-being of the community.

Extensive beds of marl are found in different parts of the county and, before the introduction of railroads, they were the chief dependence of those who used mortar in the construction of buildings; but, as the mortar made with burned marl did not endure exposure to the weather, its use was abandoned when railways carried there a superior article.

No mounds, or mound builders earth-works, could be learned ot in this county, though the implements, charms and other stones of nameless forms and uses, supposed to have been fashioned and used by that lost people, have been frequently picked up on the surface or turned up by the plow share.

ELKHART COUNTY.

This county joins the State of Michigan on the north, is bounded on the east by Lagrange and Noble counties, on the south by Kosciusko, and on the west by Marshall and St. Joseph.

It was organized in 1830, and here was erected the first court house, in Indiana, north of tha Wabash river. At that date, all the territory now constituting the counties of Lagrange and Steuben and the north part of Dekalb and Noble, was included in the civil township of Mongoquanong, and under the jurisdiction of Elkhart county. The census of 1830 gave (exclusive of the large township above named,) a population of nine hundred and thirty-five; in 1870 the inhabitants numbered twenty-six thousand and twenty-six, to which some thousands have been added since that date.

This county is twenty-two and a half miles from north to south, twenty-one from east to west and has an area of 472.5 square miles. It was named after Elkhart river, which received its name from an island near the mouth,

in the outline of which, the Indians saw a fancied resemblance to the heart of an elk.

A portion, perhaps one-third, of the surface was at the time of the first settlement covered with a growth of very large trees and a dense undergrowth of bushes and shrubs; the remainder is mostly "burr oak openings" and prairie, while a small percent is covered with peat bogs, lakes and marshes. The soil of the "openings" is a sandy loam with clay subsoil, and highly esteemed for its large yield of wheat and grass; after years of successive cropping this is promptly restored to its original productiveness by turning under a crop of clover. The strong clay soil of the woodland is very productive, especially of corn and the grasses. The black peaty loam of the prairies and drained swamps is famous for corn and grass, except during seasons of long drought.

Apples, grapes and other fruits are very generally cultivated and, when not cut off by late frosts, are a source of profit to the grower. Cranberries are a natural production of some of the marshes and though no attention has been paid to their cultivation, they constitute an important interest with some classes of the community. Careful planting and tillage of this important fruit, on selected ground would return as large a per cent as any other crop for which the same character of soil is adapted.

The timber has been lavishly sacrificed to the great demand for economic uses, yet the following species are found in considerable quantities; Beech, White, Burr and Black Oak, Maple, Elm, Ash, Hickory, Poplar, Sycamore, Cherry and Black Walnut; Tamarack was abundant until the draining and drying of the swamps invited the prairie fires to sweep over them and destroy the timber.

The largest stream in the county—the St. Joseph river—enters from the State of Michigan, about six miles west of the northeast corner and flows in a southwest course into St. Joseph county. Its principal tributaries are Elkhart, Little Elkhart and Christian rivers; these with many other smaller streams and lakes, water every part. The drainage

is wholly into the St. Joseph, except a small district in the southwest corner, from which the streams find their way to the Kankakee river.

At Goshen, the county seat, the Elkhart river has been dammed and has a fall of eighteen feet, which, with the present average annual flow of water, gives fifteen hundred horse-power, equivalent to one hundred and fifty run of burrs. This, at present, is but partly utilized; the following are run by water: Two flouring mills, three furniture factories, one woolen, one saw and one oil mill; in addition to which, other manufacturing establishments, using steam power, are located in and about this attractive commercial point, which is surrounded by a productive agricultural district and has ample railway facilities over the Air Line branch of the Lake Shore & Michigan Southern and the Cincinnati, Wabash & Michigan railroads.

Elkhart, a rapidly growing place and important manufacturing center is situated at the confluence of the Elkhart, St. Joseph and Christian rivers, all of which are dammed at this point, affording an aggregate of eight thousand three hundred horse-power.*

Enterprising capitalists have availed themselves of this grand and permanent supply of power, and several mills and factories are completed and others in course of construction; among those in operation are three flouring, two paper and three planing mills, one wagon, one starch and three furniture factories, several saw mills and other smaller establishments. Others using steam as a motor, are located near the town; prominent among which may be mentioned the repair shops of the western division of the Lake Shore & Michigan Southern Railroad. These are extensive works and give employment to several hundred skilled mechanics. The pay roll of the Company, at this point, amounts to seventy thousand dollars per month. The principal building, of the repair shops, is six hundred feet long and one hundred and twenty wide, with four wings, each one

*Estimated by John W. Irwin, Hydraulic Engineer.

hundred feet long. The establishment is furnished with all the necessary machinery for building and repairing locomotive engines and cars. A gigantic Corliss engine furnishes, silently and uninterruptedly, the power required. In addition to these shops, the Railroad Company have, at this point, an immense "round house" for sheltering locomotive engines, foundries, store-houses for fuel and general railroad supplies, a comfortable, tastefully arranged library and reading room for employees of the company, and "quarters" for engineers and firemen when off duty. Near the junction of the Air Line Branch of the L. S. & M. S. R. R., a commodious passenger depot is located, in which the local railway officials have neat and convenient offices, and to which is, also, attached a first-class eating house where all trains stop for meals.

In addition to the fine water power furnished by the St. Joseph and Elkhart rivers at Goshen and Elkhart, other valuable mill sites are found on these streams, especially at the sylvan village of Bristol on the main line of the L. S. & M. S. railroad, at the confluence of the Little Elkhart and St. Joseph rivers. At this point the water power, of these two streams, offer facilities, for the erection of mills and factories, not surpassed in the State.

Besides the towns of Elkhart, Goshen and Bristol, the following thriving points are named in the order of their population, as reported by the census of 1870, viz.: Waukarusa, Benton, Locke, New Paris and Millersburg.

This county has, within its borders, a few lakes, the most important of which are: Boot, Cooley, Heaton, Mud and Simonton, in the northwest corner, and a number of smaller ones in the southern part. Like those in the neighboring counties they contain great numbers of fish, and are the popular resorts of picnic parties and persons in quest of piscatorial sports.

The Lake Shore & Michigan Southern railroad crosses in an east-west direction, passing into Michigan in the northeast corner of the county. The Air Line Branch, of the above road, diverges from the main line at Elkhart

running southeast through the county seat and thence to Toledo. The Cincinnati, Wabash & Michigan railroad connects with the Air Line at Goshen and is running from that point, in a southerly direction, to Marion, Grant county, with a fair prospect of being completed to Cincinnati. The route of the proposed Chicago & Canada Southern railroad crosses the southern border in an east-west course.

Extensive deposits of peat occur in the low lands; and where the bogs or marshes have been drained and the reclaimed land cultivated, the presence of peat adds a wonderful degree of fertility to the soil, returning fine crops of corn and grass. The great thickness of some of these deposits will furnish an easily cultivated soil of inexhaustible fertility for centuries to come and be none the less valuable when resorted to, to supply the demand for fuel.

Considerable beds of bog iron ore are known to exist in some of the marshes, but not in sufficient quantity to pay for digging.

Brick clay, is abundant in easily accessible beds, of both varieties for making red and buff colored brick; the latter known as "Milwaukee brick," are shipped to different parts of the country, where they are in demand for the ornamentation of public buildings, being alternated with those of a red color, or arranged to form the outlines of fanciful figures, affording a pleasant relief to the monotony of the prevailing color.

Heavy beds of marl are common, the lime from which, is so far below the standard required for durable masonry that these deposits cannot be of any economic value until long continued cultivation has reduced the soil far below its present degree of productiveness, when the demand for a fertilizer will find a corresponding supply in these calcareous deposits.

The feasibility of draining the low marshy lands in the southern part of this county, and those to the west, bordering on the Kankakee river, has been demonstrated by an organization of the citizens, and the construction of a ditch

through a marsh lying south of Elkhart. It was made five feet deep and ten feet wide, at a cost of eleven hundred dollars per mile, or about nineteen cents per lineal foot. The assessment on the adjoining land for the cost of this ditch was but little more than the value of the first crop of hay gathered from the reclaimed marsh.

Some years ago a well was sunk, at the town of Elkhart, to a depth of one hundred and twenty-five feet with the hope of securing an artesian flow of water, but the drill coming in contact with boulders, which offered a greater resistance than any material previously encountered, the projectors became discouraged and further drilling was discontinued. The material passed through, for the first twenty-five feet, was gravel, and the whole of the succeeding one hundred feet was "hard pan" or indurated glacial clay with occasional thin strata of quicksand.

No mounds or other evidences of a prolonged residence of the Mound Builders were reported in this district. The stone spear points and arrow heads, picked up from the surface, were as probably lost there by the American Indians during their hunting or hostile excursions, as by the Mound Builders at an earlier period of time, and until a definite line, sustained by conclusive evidence, can be drawn between the different implements made and used by these widely distinct races, the true history of these initial steps in the mechanic arts, must remain a matter of conjecture.

ST. JOSEPH COUNTY.

This county is bounded on the north by the State of Michigan, on the east by Elkhart county, on the south by Marshall and Starke, and on the west by Laporte. It encloses an area of four hundred and seventy-seven square miles, was organized in 1830 and was originally nearly double its present size; at that time the population was but

two hundred and eighty-seven, the census of 1870 returned an enumeration of twenty-five thousand three hundred and twenty-two, showing in a period of forty years a remarkable increase for a community, which has been until quite recently, almost exclusively agricultural. The surface of this county is agreeably diversified with prairies, "oak openings" and rolling timber lands; the strong, dark soil of the latter, with a sub-soil of stiff clay is in good repute for its unfailing yield of all the products of the farm in this region of country. The light, sandy soil of the "openings" is easily cultivated and rivals the former in productiveness when the growth is not arrested by continued drought, the same may be said of the loamy mold of the prairies, the inexhaustible fertility of which, causes them to rank among the most desirable farm lands in this region. Wheat, corn, rye, oats, potatoes, clover, blue-grass, timothy and all the fruits, adapted to the latitude, are grown to great perfection on these varied soils. Agriculture has here attained the dignity of a science and is studied and practiced with an eminent degree of intelligent energy.

A few years ago numerous small tracts of low, marshy ground, too wet for cultivation, were known in the county, but the remarkable fertility of the soil, in these peaty flats, has induced the owners to resort to draining by ditches, and at this time many of them are under cultivation, producing the finest crops of corn and hay. Kankakee lake, two miles west of South Bend, was once surrounded by a marsh, of several thousand acres, which has been ditched and drained, and a large area of once impassable peat bogs reclaimed and cultivat d, and ranks among the most fertile soils of the State. These lands, once thoroughly drained and, after a few year's cultivation, set in blue-grass, are unsurpassed for grazing purposes. The black, peaty soil, varying from five to fifteen feet in depth, is practically inexhaustible and may be continually cropped for all time to come.

Within two miles of South Bend, is the eastern terminus of one of the most extensive peat beds in the world, being

three miles in width and extending westward, down the valley of the Kankakee for more than sixty miles. It varies from five to fifty feet in thickness, and when properly prepared, becomes a fair article of fuel for all domestic uses; though not a rival of Indiana block coal, or the anthracite of Pennsylvania, it is preferable to much of the sulphury clod burned in stoves and under steam boilers throughout the western states. Peat yields a fair proportion of rich illuminating gas, and probably, the time is not far distant when it will be utilized for that purpose.

The enormous consumption of wood and coal on railways may necessitate the working of these peat beds, for fuel, at an earlier date than is at present contemplated. The officers of the University of Notre Dame du Lac, near South Bend, have experimented with this fuel, and report good results.

St. Joseph county had, at the date of the first settlements a limited amount of heavy timber, but the steady drain on it for fuel and manufacturing purposes has materially reduced the original supply. In the remaining forests may be found White and Black Oak, Beech, Elm, Ash, Basswood, Hickory, Sycamore and a small quantity of Black Walnut.

Several lakes are located in the western part; the following are named on the county map: Bass, Bolins, Cedar, Chain, Clear, Cranberry, Deer, Dock, Esmey's, Fish, Goose, Grass, Kankakee, Mud, Ruples, Twin and Wharton's. Many smaller sheets of water, mere ponds, are seen, some of which have been partly drained; others are being gradually filled by the annual encroachment of grass and aquatic plants, on the shallow margins, which, in time, will fill the basins, and waving fields of cereals and grasses will succeed the polliwog and terrapin.

This county is watered by the lakes above named and the St. Joseph and Kankakee rivers and their tributaries. St. Joseph river enters a little north of the middle of the eastern boundary, runs westerly about ten miles and turns north and crosses into the State of Michigan.

Historical data points to LaSalle as the discoverer of this

river, in the year 1679. He explored the great Lakes in the "Griffin," a vessel built and launched on the Niagara river. With Hennepin, Tonti, and a few followers, he built a fort at the mouth of the St. Joseph river, then ascended that stream to the portage, near the present site of South Bend, crossed to the The-au-ki-ki or Kankakee and sailed down that stream to the Illinois.

The St. Joseph is the most important stream in this part of the State, its uniformly rapid current, unfailing supply of water and high banks afford opportunities for hydraulic power, which might be envied by the manufacturing princes of Lowell or Manchester.

In 1832, Alex. Coquillard dug a race-way from Lake Kankakee, two miles west of South Bend, to the St. Joseph river, and secured, from the flow of water, sufficient power to run a grist mill and saw mill. This power was utilized until the construction of the present dam across the St. Joseph at that point.

The prophetic vision of a few enterprising capitalists, then incorporated as the St. Joseph Iron Company, seeing the commercial value of the swift gliding current of the stream, secured the right and constructed the first dam on the river at Mishawaka,* in 1835, which still stands a monument to the skill and energy of its projectors. The hydraulic power, at this place, is equal to any on the river, and though not all utilized, is partly appropriated for running flouring and saw mills, furniture, wagon, edge tool, agricultural implement and woollen factories and plaining mills.

In 1833 the "St. Joseph Iron Company" erected a blast furnace at Mishawaka and continued to make bar iron from the bog ore dug from the prairie marshes in the vicinity until 1856, when a falling off in the supply of ore caused the discontinuance of the furnace. This company still controls the hydraulic power and is engaged in various manufacturing enterprises.

*Indian word for "swift water."

About four miles west of this place, where the river makes a sudden turn to the north and forms the *bend* from which the town of South Bend takes its name, a dam has been erected and furnishes many eligible mill sites and a great amount of unfailing power. This has become a noted point for the manufacture of flour, furniture, paper, agricultural implements, wagons, carriages and sleighs, clover threshers, sash, doors, blinds, pumps, etc., etc.

Both this town and Mishawaka, being connected by the Lake Shore & Michigan Southern railroad with the markets of the east and west, and lying within convenient reach of the great lumber regions of Michigan, offer unusual attractions to persons wishing to engage in manufacturing. Other points on this river are as available for the erection of dams as the two above named, and the amount of hydraulic power this stream might be caused to afford, is almost incalculable.

South Bend is the county seat of St. Joseph county and has a population of over eight thousand, it is a thrifty and enterprising place and surrounded by a highly cultivated district of unsurpassed fertility.

Mishawaka, the second in population in the county, is an important commercial center, and has a population of over three thousand.

The Lake Shore & Michigan Southern railroad crosses the county in an east-west direction. The Peninsular Railroad of Michigan crosses in a northeast and southwest course, passes through the county seat and connects with Chicago and central Michigan. The Baltimore, Pittsburg & Chicago railroad is graded across the southwest corner, and the Chicago & Canada Southern railroad is projected to cross the southern tier of townships.

Bog iron ore has been found in several places in the county, and was successfully worked, for a number of years, in a furnace at Mishawaka, as stated in another part of this report. Although this ore is apparently abundant at some points, and yields a superior article of iron, yet the expense of removing the overlying earth so

increases the cost of the ore that it cannot be furnished in competition with the richer ores of the Lake Superior and Missouri iron districts

The marl beds, in this as in adjoining counties, may be resorted to for fertilizing material when the clay soil shall have been worn thin by long continued cultivation.

About a mile and a half north of South Bend, on a somewhat elevated table land, amid crystal lakes and sylvan groves, is located the University of Notre Dame du Lac.

In 1832 the Rev. Stephen D. Badin secured a large tract of land at this point, with a view of establishing the present Educational Institution, which was founded in 1842, by the Fathers of the Congregation of the Holy Cross, with the very Rev. E. Sorin at the head. By zealous devotion to the moral, social and educational welfare of the youths placed under their charge, the Rev. Fathers have raised this Institution to the front rank. Rev. A. Lemonier is President and the number of pupils four hundred and seventy.

A short distance from Notre Dame, near the St Joseph river, the Sisters of the Holy Cross (under the direction of Mother Superior, Mary of St. Angela,) have established St. Mary's Academy for the education of young ladies. This institution has attained a high rank among its rivals and opened the fall term of 1873 with an attendance of two hundred and twenty-five.

LAPORTE COUNTY.

Laporte county was organized in 1832, and is bounded on the north by the State of Michigan, on the east by St. Joseph county, and on the south by Starke and on the west by Porter. It received its name from Door (*La porte*) prairie which was named, by the early French settlers, from a narrow opening in the timber through which the prairie was approached. The county contains five hundred and

sixty two square miles and in 1840, the first census after the organization, it had a population of eight thousand one hundred and eighty-four, which in 1870 numbered twenty-seven thousand and sixty-two.

Though a few French were numbered among the first settlers, the greater portion of the present population trace their ancestry to New York, Pennsylvania and New England and retain, in a marked degree the characteristic habits, thrift and energy of their forefathers.

The northern part, about one third of the whole area, is somewhat broken and hilly and was originally covered with timber. White pines of large growth, occurred near Lake Michigan, which have been cut away until but few trees, large enough for saw logs are left standing. Near the Lake shore small white oaks are abundant, while further inland, on the hills, black oak and hickory supplant the first named species. The soil of the hilly portion is a stiff blue clay with occasional beds of gravel or sand, while that near the Lake is a clean white sand. The clay soil is thin and only moderately productive. Springs of clear, cold water are not uncommon among the hills, and small marshy spots and peat bogs occur on the highest lands.

The central and southern parts are mostly prairie, dotted over with groves of burr oak and pig-nut hickory, elm, sugar tree, bass wood and cherry.

The two principal prairies are Rolling and Door or Laporte. The first named lies in the eastern part of the county and the latter in the central and western part. The soil of these is a light sandy loam of exceeding fertility and easily cultivated, and, from the first settlement, has been held in high esteem for the production of cereals, grasses and fruits. These high, rolling, fertile lands, dotted over with small groves of timber for the supply of fuel and building material and being easily brought under cultivation, offered irresistable temptations to the pioneer agriculturist, and insured the early settlement and improvement of all this beautiful domain, almost every acre of which, is now enclosed and annually yields its share of some special crop.

The limited supply of timber has rendered the cultivation of hedges a subject of serious interest in this region, and here may be seen, miles of Osage-orange or Bois d'arc (*Maclura aurantiaca,*) hedge, very thrifty and apparently well suited to this soil and climate.

Small streams of water traverse these prairies in a southerly direction and flow into the broad, sluggish Kankakee, which runs westwardly across the southern border of the county. Along this stream there is a broad, wet marsh, a great peat bed, which is, in some places forty feet deep, and covered with a rank growth of marsh grass and flowering plants. A reasonable expenditure of engineering skill and labor would drain the greater portion of these wet lands and render them very desirable for grazing or the production of hay.

North of and near the town of Laporte, are six or seven lakes varying, from a quarter of a mile, to a mile and a half, in length and covering, in the aggregate, several thousand acres of land. They are, usually, shallow near the edges, the depth increasing as the central part is approached, and there ranging from ten to fifty feet. Some are entirely free from any growth of vegetation and are remarkably clear and mirror like when unruffled by the winds, while others, especially those which receive considerable drainage from the adjoining lands are thickly set with aquatic plants of the water lily family. *Nymphæa odorata* and *Nuphar advena* are very abundant, covering the surface of the water with their large rounded leaves and filling the lake with an enormous growth of tubers, roots and leaf stalks; compact matted masses of roots have been cut through for a thickness of six feet; this rapid accumulation of organic matter, aided by the drainage washings after every shower, will build up the bottom above the present water level and, in time, a marsh will succeed the lake.

The water chinquepin (*Nelumbium luteum*) is occasionally seen in some of the less frequented lakes, where its broad leaves furnish shelter for the smaller aquatic animals and the great white flowers share their perfume with the passing breeze.

These lakes have, recently, been connected, one with an other, by a ditch broad and wide enough to allow the passage of a small steamboat—the "Viola"—which was placed there in the summer of 1873 and runs the circuit of the connected lakes, about ten miles, for the accomodation of tourists and pic-nic parties.

These, like other lakes in northern Indiana, have been subject to fluctuation of surface levels, or a gradual sinking away of the water, from five to seven feet, during a period of from six to ten years and, in turn, as gradually rising again, to or near, its orginal level in about the same length of time. This oscillation has continued through unequal periods of time since the earliest observation of white men, and, doubtless dates back to the time when the glacial sea retired and left these basins in their present isolated situation.

Before communication was opened, by ditching, there was a difference of levels in adjoining lakes; the water in one, at times, standing several inches higher than in the next.

The same phenomenon was observed in adjacent lakes in Steuben county.

The annual rainfall, recorded through a series of years, does not correspond to the oscillation of the water levels of these lakes, nor have they been observed to rise any more rapidly during a wet, than during a dry season, or vice versa; but rather to continue to the maximum during a period of rising, or to the minimum during a period of subsidence.

Until within the past decade these lakes have not been of much economic value to the citizens of the town or county. Beyond affording ice and fish for local use they were but little more than a cluster of glittering jewels, heirlooms of a past geologic age, set in the seasons changing tints and and lying carelessly upon the bosom of the reigning goddess—Ceres. But the constantly growing demand for some artificial means ot reducing the temperature of many articles of diet and almost all beverages, has rendered the

item of ice nearly as much of a necessity during the summer months as fuel is through the winter. The uniformly cold winters of the latitude of Laporte renders the ice crop of the lakes as certain as the wheat crop of the adjoining prairies. Capitalists have availed themselves of these conditions and erected commodious houses, which are annually filled with the spontaneous winter production of the clear, pure lakes.

Cutting, storing and shipping ice has become an important industry at this place as the following statement will show.

In the winter of 1873-4, forty-five houses, holding two thousand tons each, were filled with ice, in addition to which, some thousands of tons were shipped, direct from the lake for storage in Indianapolis and elsewhere. John Hilt of Laporte and V. T. Malott of Indianapolis, own twenty-six houses and annually store over fifty thousand tons, the whole of which is shipped, by railroad, to Indianapolis, Louisville and other points. Thompson & Co. are also extensive dealers and ship the greater portion of their ice to Chicago. Several other parties have houses here and ship to Chicago, Lafayette, Indianapolis, Cincinnati, Louisville and intermediate places.

These are but the initial steps in a business which will grow with each succeeding year and become a leading interest in the commerce of this section of country, not only returning a remunerative per cent on the capital invested, but furnishing employment to the laboring classes during a season when many, would otherwise, feel the pinching hand of want.

Laporte, the capital of Laporte county, is pleasantly situated on the north side of Door Prairie, immediately adjoining the lakes referred to on a preceding page. It is a little north of the geographical center of the county, and has a population of about nine thousand. The town is growing rapidly and has recently added the metropolitan features of gas and water works. Among the manufacturing establishments may be mentioned flouring mills,

furniture, agricultural implement, wheel and sash and door factories; machine shops, where are manufactured threshing machines, portable engines, water wheels, etc., and many other minor establishments.

The Lake Shore & Michigan Southern and the Indianapolis, Peru & Chicago railways place this town in direct communication with the principal cities and markets of the country, affording facilities, equal to any in the north part of the State, for the collection of raw material and the sale of manufactured articles.

Two miles north of the town of Laporte, is the highest ridge of land in the county, which, by barometric measurement, is two hundred and seventy feet above Lake Michigan, only eleven miles distant. This crest divides the drainage which finds its way into the Lake from that which flows into the Mississippi river,

Passing this water shed, in the direction of Lake Michigan, we find a marginal belt of lower lands descending gradually to the north, the surface of which is marked with elevations known as "lake ridges," generally of clean washed sand, and lying nearly parallel to the lake shore. These ridges of sand mark the ancient shore lines of the lake, where its subsidence was arrested for a greater or less period of time.

That these successive ridges were, in turn, the shore lines of the lake, is clearly inferable, when we see the winds and waves repeating the same process at Michigan .City, at the present time. Each succeeding wave brings up, from the depths of the lake, its small cargo of clean, white sand, and lands it well upon the beach. As soon as a change in the direction of the wind drives the water out and allows the sand to dry, it is carried by the same invisible force and piled up at the first atmospheric eddy produced by the trees and bushes which usually grow near the water line. The process of building up is necessarily gradual, and the well rooted vegetation reproduces itself on the top and sides of the ridge, and in the course of time a knoll, or hill, or range

of hills is formed, from one hundred to one hundred and seventy-five feet in hight.

If, from any cause, this protective growth of vegetation is destroyed, the unshielded sand is deprived of moisture by the direct rays of the sun, the decaying rootlets lose their power of clasping and binding the parts together, and the loosened sand, once more at the mercy of the wind, is drifted and scattered over the adjoining country. A notable example of this is seen near the mouth of the harbor at Michigan City. The sand hill known as "Hoosier Slide," originally covered with small white oaks and other hardy vegetation, was, at the time of Prof. Owen's visit, in Sept. 1860, one hundred and seventy-five feet high; subsequently, the trees were cut away for fuel, since which time it has been an unresisting victim of the winds, and now (1874) it is but one hundred and twenty feet above the lake.

The first ridge, along the present shore line, rises above the water level from thirty to eighty-five feet, this is broken at irregular intervals by valleys, at oblique angles, and occasionally a tall peak rises many feet above its fellows, a space of half a mile succeeds this ridge, having an elevation of fifteen to twenty feet; on this is built the town of Michigan City. The top of the second beach or ridge is fifty feet, and the half mile of valley beyond is thirty-five feet above the water. The third beach is forty-five feet, the fourth is ninety-five and the fifth is two hundred and twenty-five feet above the lake. It may be remarked that the fourth beach line contains a considerable amount of gravel, perhaps indicating a fixed water level for a, comparatively, long period of time.

The shallow portions of the present lake, near the shore, are uniformly floored with sand, but in the deep central areas the bottom is composed of stiff, tenacious clay, intercalating partings or pockets of sand, from whence, probably, comes the supply which is, constantly, being piled up and drifted about the shores by the wind. It may be inferred

that the ancient lake was governed by a like law, as the railway cuts which traverse these wide, descending shore lines, frequently discover beds of clay, (the Erie clay of Canadian Geologists) and wherever this clay is pierced by wells, the supply of water is found in the sand partings.

No continuous sand ridges are found beyond the fifth from the lake, though for some distance further inland the valleys and hollows are, more or less, floored with this wave-washed material. The lakes in the vicinity of Laporte are south of the water-shed and no evidences are traceable of their having been a part of ancient Lake Michigan since the subsidence of the glacial sea.

Michigan City is the second town in size, has a population of about six thousand and is situated on Lake Michigan in the northwest corner of the county. Traill creek, a small stream coming from the hills to the south, passes through the town; the mouth of this creek has been deepened and widened and docks constructed, affording anchorage and protection to the vessels which ply between this and other ports on the great lakes. Branch railway tracks run along the docks and every facility is furnished for loading or unloading the merchandise transhipped at this point. The United States government has, at different times, made small appropriations for improving this harbor and it is now one of the best on the south end of the Lake.

Great quantities of lumber are annually received here, from the north, for shipment by rail to the interior. The following statistics were furnished by Capt. E. Bennett, U. S. officer in charge of the Harbor.

During the year 1873 the following merchandise was received at this port, for transportation inland:

45,960,000 feet of sawed lumber.
45,132,000 shingles.
19,541,000 pieces of lath.
8,300 tons of iron ore.

And for shipment, by water, to other ports, the following:

1512 tons of Indiana block coal.
1110 tons of nut coal.
100 tons of anthracite coal.
4000 barrels of lime and cement.
150 tons of hay.

Quantities of fish are taken in the Lake and shipped to various points to the south and west, furnishing employment to several vessels and a number of men. The fish are taken in nets which are from four to five feet wide and twenty to thirty feet long. These are carried in vessels eight or ten miles from shore and sunk to the bottom where the water is from one hundred and fifty to two hundred feet deep, buoys and flags marking the locality. White fish (*Corregonus alosa*) is the most abundant species, constituting nine-tenths of the whole number taken, the flesh of which is pure white, juicy and when properly broiled, ranks with epicures as the most delicious fish taken in western waters. The Maskinonge* or Muskalunge (*Esox estor.*) is abundant and frequently taken in nets with White-fish, and, also, Mackinaw trout (*Salmo amethystus,*) both of which are highly esteemed and command a ready sale in all the markets of the west; the demand for all the species being, usually greater than the supply.

Fishing is pursued, as a regular business, throughout the year, except during the coldest winter months. For the year 1873 the shipments of fish from Michigan City were about two hundred and seventy tons, worth, at wholesale, twenty-seven thousand dollars.

Ornithologists will be interested in learning that a species of ducks known as "old wives" (*Harelda glacialis,*) are

*From the Ojibwa Indian name, "Maskanonja," meaning "long snout."

frequently taken in the nets, set by the fisherman, on the bottom of the lake, in one hundred and eighty feet of water. However incredible it may seem that water foul should dive to such a depth, the fishermen assert that these birds are often found in the nets, and on one occasion they report the capture of three hundred at one haul.

The Michigan Central railroad Company have large and well arranged repair shops at this place, giving employment to a number of skilled mechanics. The Indianapolis, Peru & Chicago, and the Louisville & Chicago railroads have their northern termini here, and the latter have established a car factory and, also, shops for general repairing.

About a mile west of the town, on a dry, sandy plain, is located the Northern Indiana Penitentiary, where cooperaing, wagon and chair making are conducted on an extensive scale, the labor being performed by the convicts.

Within the walls of the Penitentiary a well has been bored to the depth of five hundred and forty-one and a half feet, of which the following is a section:

Surface sand	48 ft. 00 in.
Clay	4 ft. 00 in.
Sand	24 ft. 00 in.
Clay	66 ft. 00 in.
Sand	30 ft. 00 in.
Slate (Marcellus shale)	76 ft. 00 in.
Limestone (Upper silurian, with fossils)	293 ft. 06 in.
	541 ft. 06 in.

This bore terminates in a porous limestone rock, from which flows a stream of mineral water, strongly impregnated with sulphuretted hydrogen. The water rises twenty-two feet above the surface of the ground, discharges about three hundred gallons per minute and has a temperature of 57° Fahr.

A qualitative analysis, of the water was made, by a chemist

in Chicago (name not given) at the request of the Prison authorities, which indicated the presence of the following constituents:

Carbonate of lime,
Bi-carbonate of magnesia,
Bi-carbonate of soda,
Bi-carbonate of potash,
Sulphate of soda,
Chloride of sodium,
Chloride of potassium.

Gives an alkaline reaction and is strongly charged with sulphuretted hydrogen and carbonic acid gas.

It is a decided alterative and may prove remedial in diseases of the liver, kidneys and skin.

The soil in the vicinity of the town, is too sandy for the production of cereals and grasses. Apples and pears do well and the sandy knolls are especially adapted to the growth of the Huckleberry bush, which is native and very prolific. The fruit is highly esteemed and much sought after for table use; of the small fruits which ripen in midsummer, it ranks next to the blackberry in popularity, having a delicate flavor and generally considered wholesome. The first marketable berries are gathered in July and an abundant daily crop is produced for about six weeks. The shipments, in the hight of the season reach near three hundred bushels per day, being, to the berry gatherers, a dispensation of ten thousand dollars per annum.

The Cranberry plant is indigenous to the marshy lands of this region, and when the season of growth is not too dry the wild vines produce good crops; but a much greater yield, of larger and better flavored berries, is secured when the vines are planted on drained marsh land which has been prepared by cultivation and the natural growth ot bushes, weeds and grass destroyed, and which can be flooded, or covered with water, during the winter.

The ease with which this fruit can be kept through the winter months, without decomposition or change, has ren-

dered it very popular with provident house-wives, and no public or family dinner is considered complete without an accompanying dish of this important and healthful appetizer.

About two miles northwest of Michigan City is a marsh of sixty acres of planted or cultivated vines, which, it is asserted, yields, annually from one hundred to two hundred bushels of berries per acre. This is, doubtless, a very profitable industry, and one that may be embarked in with a small cash outlay.

The timber of this county is more remarkable for variety than for quantity. White and Red Oak, Hickory and Tamarack are found along the marshes in the southern part, while the prairies in the central portion are dotted over with groves composed of Burr Oak, Sugar-tree, Elm, Pignut and Shell-bark Hickory, Cherry, Bass-wood and Sassafras. In the hilly portions, to the north and east, are seen Beech, White and Red Oak, Elm, Poplar and Sugar-tree, White and Blue Ash, Shell-bark Hickory, Bass-wood, Black and White Walnut, Cherry, Sycamore, Sassafras, Cottonwood, Tamarack, with a few Red Cedars, and as we approach the lake, the once abundant White Pine, is seen in small groves.

Bog iron ore occurs in considerable quantities in the marshes along the Kankakee river, and when some plan has been devised for converting the peat, with which it is associated, into fuel adapted to use in a blast furnace, each may add to the value of the other and, mutually, tend to bring the much abused Kankakee marsh into more favorable notice.

The almost universal desire of agricultural communities for railway connection with the chief markets of the country would seem to have been fully gratified, if not surfeited, in this county.

Of the following list of railways, seven are in operation and two in course of construction:

The Lake Shore & Michigan Southern railroad crosses the county in an east-west direction; the Indianapolis, Peru & Chicago railroad crosses in a north-south course, both

passing through the county seat, and the latter connects at Michigan City with the Michigan Central Railroad which skirts the shore of the Lake in the northwest corner of the county. The Louisville & Chicago Railroad passes in a due north-south line along the west edge, terminating at Michigan City. The Peninsular Railway of Michigan crosses near the center in a northeast-southwest course. The Pittsburg, Fort Wayne & Chicago Railroad passes over the southwest corner, and a short distance south of that is the line of the Cincinnati, Logansport & Chicago road. The Baltimore, Pittsburg & Chicago Railroad is graded across the southern end, and the proposed route of the Chicago & Canada Southern has been surveyed near the same path.

About twelve miles south of Laporte, on the low bank of a small creek, which is tributary to the Kankakee river, are several mounds, built up almost entirely of sand and ranging from six to twenty feet in hight; some of these were dug into, by the citizens of the neighborhood, and one human skull, two copper hatchets, two broken earthen vessels and a pipe, taken out. The latter is carved from a dark-red clay stone, (not from the red pipe stone quarry of Minnesota,) and is a unique specimen of pre-historic art, unmistakably intended to perpetuate, in a convenient and useful form, the graceful outline and seductive charms of a favorite mistress; a thought, though rude in its inception and execution, the ante-type of that refined devotion which is expressed in marble and on canvass by the most enlightened people of modern times.

Others of this group of tumuli were, subsequently, opened under the direction of Dr. T. Higday, of Laporte, (to whom I am indebted for information.) In one they sunk a pit to a depth of thirteen feet, discovering three human skeletons, near the heads of which were two copper hatchets, two copper needles, a piece of galena, (sulphuret of lead,) several pieces of mica and a pipe carved to represent some animal, perhaps a ground-hog, (*Arctomus monax*), also one earthern vessel containing black mold.

The largest one of the group, near the water's edge, had been partly cut away by the current of the stream, this was opened by removing the overlying earth with road scrapers and teams; thirteen feet from the top a layer of ashes was found, two inches thick near the center, and three feet deeper, two adult skeletons were exposed, one of which was resting upon the decayed remains of what was supposed to have been a log of wood. Along with these skeletons were found a pipe, a copper needle, fragments of pottery and part of a marine shell (*Cardium magnum.*) Two smaller mounds were opened, revealing nothing, which would indicate that they were erected for other than sepulchral uses.

The black mold contained in the vessels above mentioned, and in many others found in similar situations, is regarded by some archæologists as the remains of food, placed there at the time of burial, for sustenance until the deceased had become settled in the "happy hunting ground" beyond the grave.

This is a reasonable inference and one around which clusters a world of interest; coming from the dark, forgotten past, as a ray of light that has bridged centuries to tell its wrondrous story; a simple, devotional act of a crude, unlettered people, pointing with unmistakable significance to their faith in that immortality to which humanity instinctively aspires.

INDEX.

ERRATA.

Page 7, line 27, for "Kadno" read "Kladno."
Page 14, line 32, for "Heuss" read "Neuss."
Page 14, line 33, for "Doitmund" read "Dortmund," and likewise throughout the paper.
Page 15, line 21, for "Lahr" read "Lahn."
Page 18, line 7, for "coals" read "coats."
Page 21, line 30, for "Galluo" read "Gallico."
Page 21, line 30, for "Frier" read "Trier."
Page 24, line 18, for "Sifel" read "Eifel."
Page 44, line 6, for "Renroth" read "Rexroth."
Page 50, line 32, for "Saar" read "Laar," and likewise throughout the paper.
Page 51, line 26, for "Herkerade" read "Sterkerade."
Page 52, line 20, for "facing" read "facon."
Page 58, line 15, for "Hanem" read "Hamm."
Page 58, line 22, for "Wachrodt" read "Nachrodt."
Page 59, line 1, for "Hobruker" read "Hobrecker."
Page 59, line 26, for "Hulte" read "Hutte."
Page 65, line 12, for "100.78" read "100.48."
Page 65, line 12, for "95.88" read "95.68."
Page 65, line 12, for "99.74" read "99.84."
Page 92, line 30, for "6750°" read "6-750.°"
Page 135, line 16, for "rapid" read "rapids."
Page 149, line 29, for "which are" read "which is."
Page 150, line 18, for "Skaws" read "W. D. Straws."
Page 151, line 8, for "larucosa" read "varicosa."
Page 151, line 33, for "J. Davis" read "W. Davis."
Page 152, line 19, for "Verys" read "Verey's."
Page 155, line 17, after "1st. Soil 4 to 6 feet" insert "2d. 2 to 3 feet of hydraulic limestone, with cherty concretions, containing dendritic crystals on the surface, 3 feet." "3d. Hydraulic limestone, pure, 10 feet." "4th. Carniferous limestone in an opening in a quarry, 22 feet."

Page 161, line 12, for "even" read "seven."
Page 165, line 36, for "Jarus" read "Jairus."
Page 169, line 22, for "Akens" read "Adkens."
Page 169, line 23, for "Akens" read "Adkens."
Page 173, line 9, for "evener" read "even."
Page 179, line 28, for "much used" read "good."
Page 181, line 6, for "100.000" read "50.000."
Page 181, line 20, for "désigned" read "destined."
Page 188, line 27, for "1813" read "1783."
Page 191, line 6, for "Kikapoo" read "Kickapoo."
Page 192, line 10, for "their" read "thin."
Page 200, line 6, after "Independence" insert ","
Page 200, line 33, for "northwestern" read "northeastern."
Page 204, line 27, for "These" read "Such."
Page 213, line 22, for "coking" read "caking."
Page 216, line 13, for "at" read "in."
Page 225, line 27, erase "the" after "and."
Page 240, line 27, after "sandstone" insert ","
Page 240, line 28, omit "," after "shale."
Page 261, line 35, for "into" read "in."
Page 276, line 24, for "coal" read "coral."
Page 325, line 13, for "or are" "or is."
Page 352, line 19, for "when" read "which,"
Page 370, line 18, for "dy" read "by."
Page 388, line 20, for "Hills" read "Rocks."